

**Enduring Psychological  
Sequelae of Electroconvulsive  
Therapy**

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Electroconvulsive Therapy

Table of Contents

	<u>Page</u>
Acknowledgements	i.
Abstract Summary	iii.
General Introduction	1.
Literature Review	
Chapter 1. The cognitive effects of depression	7.
Chapter 2. The effects of electroconvulsive stimulation on the performance of laboratory animals	29.
Chapter 3. The effects of psychotropic medica- tion on human cognitive function	39.
Chapter 4. The effects of electroconvulsive therapy on human cognitive function	47.
Methods	
A.) Psychometrics - Rationale and Description	79.
1.) Perceptual Aptitude	83.
2.) Psychomotor Speed	83.
3.) Learning	85.
4.) Memory	88.
5.) Miscellaneous Cognitive Tests	98.
6.) Lateral Dominance	103.
7.) Psychopathology	105.
B.) Subjects	108.

## Table of Contents (continued)

Methods (continued)	<u>Page</u>
C.) Pilot Studies	121.
D.) Procedure	123.
1.) Psychometric testing	123.
2.) ECT procedure	126.
E.) Design	128.
Results	
A.) Normative Studies	
1.) Test validity	132.
2.) Principal components analysis	135.
3.) Reliability, stability, inter- scorer agreement	136.
B.) Controlled study: ECT vs non-ECT group comparisons	140.
ECT group one week after treatment	148.
ECT group and non-ECT group test comparisons at four months	152.
ECT group and non-ECT group test comparisons at seven months	156.
C.) Comparison between unilateral and bilateral ECT	161.
D.) Relationships between subjective cognitive complaints, objective tests, psychopathology, and other variables	167.
Discussion	175.
References	206.
Appendix	236.

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This thesis is dedicated to my son, David Colin.

I hereby declare that this thesis has been composed and conducted by myself, with the exceptions of the above acknowledged collaboration and help.

*David J. Weeks*  
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Summary Abstract

The aim of this research was to examine whether electroconvulsive therapy (ECT) has any enduring effects on cognition when it is used to treat depressed patients. The literature concerning the effects of depression, psychotropic medication, and ECT on cognition, was reviewed. Animal analogue experiments and human clinical studies were reviewed with particular attention to followup studies. Within the clinical psychometric studies, four major aspects of cognitive function - perception, performance speed, learning and memory - were critically analyzed.

An empirical prospective study, avoiding the methodological inadequacies of the previous work and extending the length of followup, is described. The abovementioned aspects of cognitive function were compared in carefully matched groups of ECT and non-ECT treated depressives on admission, at four months and at seven months. Matched volunteer subjects were assessed to ascertain normal levels and variation of each of the psychometric tests employed, and to ascertain reliability. Three new tests were validated by correlational reference to established tests and to independent neuroradiological assessments of structural cerebral abnormalities.

ECT caused little impairment at four months and no impairment at seven months as indicated by the comprehensive

cognitive test battery. Severity of depression had a marked effect on cognitive function. Within the ECT group, bilateral ECT caused more impairment than unilateral ECT one week after a course of treatment, but three months later the differences had disappeared. Both forms of treatment were equally antidepressant. These results are discussed in terms of potential methodological criticisms and other sources of error. A synthesis is attempted to relate this study's findings to the subjective complaints of a proportion of previously treated patients. The implications of this study to clinical practice and further research are put forward.

General Introduction

In the light of the available evidence, there can be little doubt of the efficacy of electroconvulsive therapy (ECT) in the treatment of endogenous depression (Fink, 1979; Frankel, 1979). The Royal College of Psychiatry (1977) has summarized ECT's efficacy thusly: "There is substantial and incontrovertible evidence that the ECT procedure is an effective treatment in severe depressive illness."

Controlled trials of ECT as a treatment of depression have indicated a causal association of favourable outcome with ECT (Barton, 1977; Turek and Hanlon, 1977; Medical Research Council, 1965; Wilson, Vernon, Guin and Sandifer, 1963; Robin and Harris, 1962). More impressively, studies comparing real ECT with simulated ECT (West, 1981; Johnstone, Deakin, Lawler, Frith, Stevens, McPherson, and Crow, 1980; Freeman, Basson, and Crighton, 1978) have convincingly confirmed the scientific rationale of the treatment. The single double-blind comparison that arrived at contrary findings (Lambourn and Gill, 1978) was seriously weakened by the use of an atypical 'real' treatment.

Since its advent in Britain, ECT has been one of the factors which has reduced the duration of hospitalization for women with depression from a mean of 313 days prior to 1937 to about 36 to 60 days currently (Ravn, 1966;

Coryell, 1978). ECT can and does substantially truncate the length of a depressive illness. ECT is more effective than antidepressant medication in the treatment of depression (Avery and Winokur, 1977). Inpatient response studies comparing ECT with tricyclic antidepressants (Coryell, 1978) have also been encouraging. In addition, the relapse rate is no worse for ECT than for chemotherapy (Bratfos and Haug, 1965).

The ECT procedure is relatively very safe. Estimates of mortality rates directly related to ECT in its modern configuration have been between 3 and 5 per 100,000 treatments (Barker and Baker, 1959; Hesche and Röeder, 1976). There are a number of relative contraindications to ECT; these include a recent myocardial infarct or cerebrovascular accident, and severe pulmonary disease.

Mortality rates post-ECT are also comparatively low. In a follow-up study of 519 depressed patients (Avery and Winokur, 1976), the proportions of patients surviving one and three years after ECT or full therapeutic regimes of antidepressants, showed an advantage for ECT.

ECT can also be beneficial to the overall management of affective disorders and one of its major problems - treatment non-adherence. In such disorders, the disruptive consequences of medication non-adherence are



mitigated by the way symptoms develop insidiously after treatment ceases, thus blurring the cause and effect relationships for patients, relatives and professionals. Estimates of the incidence of non-compliance with pharmacotherapy in out-patient populations of identified depressed patients include estimates of 40% (Hare and Willcox, 1967), 44% (Willcox, Gillan, and Hare, 1965), 51% (Park and Lipman, 1964) and 56% (Van Putten, 1975).

The aspect of ECT most complained of by patients (Freeman and Kendell, 1980), up to 74% of them, is the side-effect of memory disturbance or memory impairment. Previous estimates (eg, Gomez, 1975) of this problem have probably underestimated the amount of worry generated by this issue, because of the methodology of the prior studies, and because of recent adverse publicity. Almost 50% of one sample of new psychiatric patients in Southampton, for instance, expressed worry about the effects of electrical shocks on the brain (Michaels and Sevitt, 1978).

As ECT is an effective and safe procedure, there is an increased need for more attention to be paid to its mode(s) of therapeutic action and to its sequelae. However, the investigation of these sequelae can be in some respects undertaken independently of investigations into clinical efficacy and mode(s) of action. The more

detached a researcher can be from the allocation of patients to treatments, from unsubstantiated opinions, and from professional career investments, the more reliance can be placed on that person's objectivity. One of the main reasons that most studies of mental health treatment effectiveness have been so fraught with needless controversy, is that the researchers have been partisans prior to, and running concurrently with, their research involvement. Therefore, it would not be unexpected that, for example, psychotherapists would tend to report more favourable outcomes for types of psychotherapy in which they themselves participated, than for those alternate therapies in which they did not so participate. In this respect, clinical psychologists, who have typically had negligible involvement with ECT, would be well placed to provide objective assessments of the neuropsychological sequelae of this treatment, provided positive efforts were made to minimize the effects of personal bias.

There are many good reasons to investigate the cognitive effects of ECT. There have been many earnest previous attempts to do this, but collectively they have not succeeded in dispelling doubts about the existence of the treatment's side effects. There are only approximate estimates of recovery curves for specific cognitive functions. Little information is available to clinicians concerning the average recovery rate for each specific

function relative to other functions. If there were seen to be no enduring cognitive side-effects, such information would reinforce the confidence with which clinicians could use a procedure that is controversial even within the medical establishment. If enduring cognitive side-effects are demonstrated, the knowledge of what these are, and to which patients they apply, could serve as a starting point for remedial or ameliorative services. Alternately, such information could provide a rational basis for prescribing other forms of convulsive treatment or antidepressant therapies for some depressed patients.

Clinical psychiatric research has many problems, some of which are common to all research, and some more peculiar to the psychiatric context and clinical setting. ECT research is no exception, but in addition has some special problems. Because it is efficacious in the treatment of severely depressed patients, ECT is seen as the treatment of choice for such patients. Because it is the treatment of choice, research requiring randomized allocation of patients would need affirmative approval from most of the psychiatric consultants in the chosen treatment centre. Such measures could be perceived as an infringement of clinical responsibility, and not in the patients' best interests. Without randomized allocation, the vagaries of a variety of treatment selection policies would need to be accommodated. This would necessitate the screening of large populations, the equating of samples on

significant control variables, or to be content with a slow, and perhaps unrepresentative, intake.

This technical problem is bound up with several ethical conundrums, or rather the balancing of superficially opposed ethics. The clinical ethic is founded on the alleviation of suffering and the absolute minimizing of undue pain and distress. The research ethic, though aiming at similar ends, is fundamentally concerned with the pursuit of knowledge. Benefits accruing from the latter usually come too late to be of immediate clinical benefit. The medical Hippocratic attitude prohibits an experiment if there is a probability or a priori reason to believe that death or injury of the subject will occur. The two ethics are not always compatible; however in clinical research the clinical ethic should take precedence. Methodological difficulties must therefore be circumvented by tenable designs and planning.

Literature ReviewChapter OneThe Cognitive Effects of Depression

Electroconvulsive treatment is most often administered in the context of severe depressive illness. Therefore it would be prudent to examine the literature concerning the effects of depression on cognitive function.

Hall and Crookes (1952) studied nineteen patients (mean age = 31) with neurotic depressive disorders, using two learning tests. The first of these tests was a paired word associate learning test, and the second was a performance test involving the learning of five different combinations of switch positions displayed on a panel. This latter test involved visual learning susceptible to verbal coding, and was also a test of psycho-motor speed. The comparison groups were a group of matched normal controls and patients with anxiety states. The depressed patients were 24% slower than the normal controls, and 41% slower than the anxiety patients. During the learning process on both tests, the depressives showed a significant tendency to "lapse" in their behaviour. A "lapse" was counted whenever the number of correct recalls on a trial fell below a level reached on the immediately preceding trial. Also, once having learned to an equivalent standard, the depressed patients subsequently tended to forget more of what they had learned.

Shapiro and Nelson (1955), studied fourteen female patients suffering from manic-depressive psychoses. These

patients had been ill on average for seven years (range 0.25 to 25 years); their mean age was 41 (range 20 - 50). They were significantly slower than a control group of neurotic patients on the Babcock error-free speed test. The ability to retain newly learned definitions after twenty four hours significantly differentiated the manic-depressives from the normals, even when vocabulary ability was held constant. Both psycho-motor slowing and retention failure correlated significantly with the degree of illness; psycho-motor slowing was found to be more sensitive than retention failure to depressive severity.

Mezez and Cohen (1961) found that depressives tended to produce and reproduce time intervals that were longer than the 30 second standard provided. Following clinical improvement, production and reproduction of time intervals became slightly, but not significantly, more accurate. At admission, 76% of these patients reported their experience of time as slow, and after treatment, 72% reported their experience of time as normal. Unfortunately, this study had no comparison group. It may be that objective temporal inaccuracy is an enduring trait of some persons who are predisposed to depression, whereas subjective temporal experience and psycho-motor slowing are more related to acute illness episodes.

Birren (1963), in his intensive study of forty seven

elderly men, found that although the presence of mild depressive symptoms had no effect on intellectual functioning, it did effect psycho-motor speed.

In terms of Pavlovian conditioned learning, it has been shown that unconditioned responses are prolonged and weak in depression. Further, conditionability decreases in depression relative to normal (Ban, 1964). Depressives typically exhibit significantly lower amplitudes of both unconditioned and conditioned responses (Ban, Choi, Lehmann, and Adamo, 1966).

Friedman's (1964) study was the most exhaustive study ever to be attempted on a large sample of severely depressed psychotic patients. Each patient was tested for a full day within the first week of their hospitalisation, and before treatment. The depressed patients (N=55) were very closely matched to normal control subjects (N=65) for age, sex, educational level, marital status, religion, nationality, and vocabulary score. This study is important because it delineated the specific areas of cognitive function in which depressives are impaired, and it excluded other areas in which there is no appreciable impairment. However, emphasis was placed on the fact that of eighty two test score comparisons between the two groups, only three achieved a respectable level of statistical significance, and six a modest level

statistical significance. This was only somewhat better than chance. Only those of Friedman's significant results that were internally consistent or have been replicated should be treated as credible. For instance, tachistoscopic recognition time for one common object, a chair, was impaired, but the tachistoscopic recognition times for a host of other common objects, letters and designs were not. Therefore, this finding should be regarded with some scepticism. On the other hand, slower reaction time to a visual signal, impaired performance on the Wechsler Digit Symbol subtest, verbal learning (both easy and difficult associability levels), reproduction of designs from memory, Necker Cube Reversal, and the Shift Test - are mutually concordant, replicated findings. These impairments can best be summarised as impairments of the following functions: psychomotor speed, attention, short-term learning and memory. Friedman also noted that the patients were more variable than the normal controls, and more often failed easy items while passing more difficult items. This is congruent with the "lapses" noted by Hall and Crookes (1952).

Perris (1966) deduced that psychotic depressives suffered from a displacement or instability of attention, which he attributed to their delusions and anxiety. He inferred this attentional disturbance on the basis of three tests: (a) the depressives' preference for colour responses over form responses during a photic stimulation condition;



(b) impaired flicker threshold; (c) electroencephalographic alpha rhythm irregularities.

Martin and Rees (1966) simultaneously measured choice reaction times and muscle action potentials in patients with a primary depressive illness, and in normal controls. These experimenters manipulated the probability that a warning light would be followed by a target tone to which the subject should respond with a hand movement. The depressives showed little discrimination to the two lights - their muscle action potentials increased as much to the light which was never followed by the tone as to the light which was always followed by the tone. For the controls, there was a significant difference in muscle action potential changes for the different lights. The authors concluded that depression is associated with poor discrimination learning.

Dilling and Rabin (1967), further investigated various aspects of subjective and objective time experience in depressives, schizophrenics and normal controls. Their first variable, Time Extension, was operationally defined as the amount of future time that a story composed about a stimulus picture spanned. The fictional stories of depressives penetrated into the future least, and the normals most. Time Orientation concerned whether a person was pre-occupied with the past, present or future. Normals were more future-oriented, and both psychotic

groups significantly less so. Time Coherence referred to the degree of logical order an individual imposes on events in any given time span. Here depressives were intermediate between schizophrenics (least coherent) and normals (most coherent). Both psychotic groups made poorer judgments than normals of a long, but not a brief, elapsed time interval. Like Mezez and Cohen (1961), it is not clear whether these deficits are reversible deficits due to the illness or more enduring personality traits.

Wyrick and Wyrick (1977) have subsequently replicated many of these earlier findings. They compared 30 severely depressed patients with 50 controls on several aspects of time experience. The depressed patients were most preoccupied with past events, and also attended more readily to more distant past events and memories. They focussed less on present and future events, and within the category of future events, attended to more imminent future events. Objectively, the depressives over-estimated intervals of 160 seconds, 240 seconds, 15 minutes, and 30 minutes. These patients subjectively confirmed these estimations, indicating that they experienced time passing slowly during the experiments. They also reported that, when well, time did not seem to pass as slowly.

Michon (1965, 1967) and Vroon (1970) have shown that

apparent time is a decreasing function of the information transmission rate, and that curves relating subjective duration to real time show an inflection point at the transition between sensory (very short-term) memory and short-term memory. Thus, duration experience appeared to be closely dependent on psychomotor speed and memory.

Hemsi, Whitehead, and Post (1968) objectively demonstrated severe, but temporary, cognitive impairment in some severely depressed elderly patients. Sixteen per cent obtained scores on a synonym learning test which were as poor as those of brain-damaged patients of the same age. An analysis of these patients' clinical features showed an association with low original intelligence, delusions, perplexity or marked thinking difficulties, and poor information about events outside the patient's immediate sphere of interest. Exogenous factors contributing to their illness were excluded, and continued observations confirmed that they were not in the early stages of dementia. Poor information for events outside the patient's immediate sphere of interest has also been found in a broader sample of depressives (Granick, 1963).

Parallelling these psychometric findings are comparable clinical findings. A retrospective search of case notes by Simon and Malamud (1966) suggested that the over-diagnosis of dementia was caused by the inadvertent

inclusion of patients with affective illnesses. Nott and Fleminger's (1975) influential follow-up study of 35 patients diagnosed as presenile dementias between 1950 and 1969 showed that only 43 per cent had actually deteriorated.

Levy and Maxwell (1968) compared ten severe depressives to ten schizophrenics and ten non-psychotic patients with respect to semantic recall. All groups were free of medication and matched on age and verbal intelligence. The tests involved the immediate repetition of series of either ten or twenty words varying in organisation from random word strings to normal sentences. Recall was always significantly worse for the depressives than the controls, and as the degree of semantic organisation was increased, the controls were able to improve at a higher rate than the depressives. The depressives did as poorly on the ten word list length as on the twenty word list length. The differences between the schizophrenics and the depressives were small at the ten word length, but the schizophrenics' improvement with increasing organisation rose more steeply than that of the depressives when the lists were increased to twenty words.

Henry, Weingartner, and Murphy (1971, 1973) found evidence linking alterations in learning, memory, and associative processes to changes in their patients' clinical states. They found evidence of impaired performance on serial and

free recall learning tasks during both depression and mania. These authors interpreted these cognitive deficits as deriving from an inability to shift information from short-term memory storage to long-term memory storage due to neurochemical transmitter abnormalities.

Whitehead (1973, 1974) performed a more detailed replication of Henry et al's (1971, 1973) findings for serial learning. She found that elderly depressives not only made fewer correct responses than remitted patients but also made fewer transposition errors (guessing less often); over three quarters of all their errors were classified as omission errors. Older depressed patients would rather not respond unless they were fairly certain of success. Overall, Whitehead's (1973) findings question the existence of a depressive deficit for immediate digit span, for the rote learning of small quantities of material, for recognition memory, and for the reproduction of meaningful material, either immediately or after a delay. However, the ill depressives did show deficits on the Synonym Learning Test, and in serial learning. Unfortunately, Whitehead (1974) used rather dated norms for some of her comparisons. These norms did not include data for people over 60 years of age, and Whitehead's (1974) sample had a mean age of 70 years. Therefore, more up to date and age-appropriate norms (e.g., Cauthen, 1977) have been used by the present author to reanalyse Whitehead's (1974) results. In fact, her ill depressives

were significantly better than matched controls on the immediate digit span (forward reading) sub-test (critical ratio 2.04,  $p < .05$ ). Also, her ill depressives were significantly inferior to matched normal controls on the immediate reproduction of meaningful material (critical ratio 2.06,  $p < .05$ ). These are the only two of Whitehead's findings that can be challenged empirically.

Nyström and Lindegård (1975), in an epidemiological study directed at ascertaining predisposing factors to depression, found a much higher prevalence of self-reported absent-mindedness amongst depressed patients (32.4%) than amongst normal control subjects (13%). Only 5% of their depressed sample were classified psychotic.

Bruder and his colleagues (Bruder, Sutton, Babkoff, Gurland, Yozawitz, and Fleiss, 1975; Bruder and Yozawitz, 1976), applying the methodology of psychophysics to a study of affective psychotics, found such patients to be less sensitive at detecting an auditory transient (a click) than were schizophrenics or non-patients. The affective patients required on average six decibels more acoustic energy to obtain the same level of signal detectability as non-patients, and five decibels more than the schizophrenic patients. These differences were statistically significant. The affective patients, however, benefited more than the other two groups by the addition of a second auditory transient. Under this

condition their reaction times to the target transient were speeded compared to their performance without it. Bruder et al (1975) used the condition with the additional transient to exclude the possible confounding effect of deficient attention on perceptual sensitivity. They then deduced that the affective psychotics had a genuine perceptual deficit, and suggested parallels to patients with auditory cortex lesions. However, their results could be interpreted in at least one other way. The majority of the schizophrenic sample were 'paranoid' or 'schizo-affective', rather than hebephrenic, catatonic, or acute. Therefore, the apparent auditory deficit could have been due to a relative deficit in concentration or vigilance on the part of the affective sample. Bruder et al (1975) admit this. In the second part of the experiment involving two-choice reaction times, the facilitation provided by the additional signal may have been an enhancement of psycho-motor speed rather than an enhancement of auditory sensitivity. This is a likelier explanation of their results, as at least 25% of their affective sample were being treated as schizophrenics, i.e., with phenothiazines, primarily chlorpromazine. This would probably have slowed the real depressives relatively more, and improved the performance of the schizophrenics (Goldberg, 1972). Finally, the affective sample was one standard deviation more anxious than the schizophrenic sample, one further factor that would have interfered with their psycho-motor processing.



Hemsley and Zawada (1976) showed that the deficit in auditory short-term memory of depressives on anti-depressants was equivalent to that of schizophrenics on phenothiazines. In their test, six random numbers were presented by alternating male and female voices. The depressed patients tended to benefit by pre-instructions to concentrate on either the male or female voice, whereas the schizophrenics did not. This showed that the distractability seen in these two psychoses may be essentially different. Quantitatively, the depressed patients showed a 46% deficit in comparison to a normal control group. Although the improvement brought about by pre-instruction for the depressives was 18% better than the post-signal instruction condition, the normal control group improved by 43% with equivalent redirection of attention.

Sternberg and Jarvik (1976) examined both short-term memory and long-term memory in twenty six hospitalised depressed patients. None of them had ever received ECT or anti-depressant medication. Their performance was compared with a matched control group and with the performance of twenty patients who had improved after twenty six days of treatment with anti-depressants. The results indicated that the depressed patients were markedly impaired in short-term memory with no impairment in long-term memory. The greater the improvement of the clinical state, the greater was the improvement in short-term



memory. Long-term memory was not influenced by the amount of therapeutic success. More specifically, the depressives were significantly worse than the control group in the earlier stages of the memory process - registration and immediate reproduction - and therefore, at the later stages of the memory process - delayed reproduction after three hours - they appeared to be worse than the controls. However, they did not forget any more previously-tested material over this period than the controls did. There were however, different responses to different kinds and levels of interference. Both groups were subject to the effects of proactive interference - interference that occurs when the unlearning of inappropriate responses fails - i.e., this would be brought about primarily by intra-experimental interference from other memory tests. But the depressed group were also subject to more intense extra-experimental interference from their ruminations and delusions.

Sternberg and Jarvik (1976) hypothesise that the extra-experimental interference, leading to deficient registration, protects the depressed patient from intra-experimental interference. Alternately, it could be argued that the two types of interference are additive, and in the face of higher levels of interference, depressed patients respond differently. Indeed, these researchers noted that the control group more often substituted previously learned inappropriate responses

than did the depressed patients. This replicated differences in guessing behaviour previously noted by Whitehead (1973, 1974).

Byrne (1976a) examined the choice reaction times of psychotic depressives, neurotic depressives, and normal controls. Utilising an apparatus that provides independent measurements of central information processing speed and peripheral motor response speed he was able to study the relative contributions of these factors. Categorising the depressives into psychotic and neurotic groups increased the within-group homogeneity and introduced a mean age difference of ten years between the groups. Byrne's results supported the hypothesis of increased response latencies in depressed patients relative to normals. This finding has been replicated in an out-patient depressive sample (Seppala, Linnoila, and Mattila, 1978). That component which reflects central processing speed was slower in both psychotic and neurotic depressives than in the normal control sample. The psychotic depressives were significantly more deficient on this variable than the neurotic depressives. The peripheral movement times distinguished both depressed groups from normals, but did not differentiate the depressed groups. The present author has reanalysed Byrne's data. Using the statistical method of partial correlations, the effects of age on the relationship between depressive severity and peripheral movement time can be held

constant. When this is done the relationship between depressive severity and movement time does not attain statistical significance for Byrne's sample of psychotic depressives, and there is no relationship at all in Byrne's combined sample of neurotic and psychotic depressives. There was a complex interaction between age, depressive severity, peripheral movement, and diagnostic sub-groupings.

Byrne (1976b) investigated the vigilance of depressed patients. Vigilance can best be conceptualised as attention sustained over a period of time. Psychotic depressives detected about two thirds fewer signals than did the neurotic depressives. (The signals were three consecutive odd numbers spoken by a consistent female voice reciting a list of random digits at one digit per second.) The normal controls detected the signals significantly better than both depressed groups. False positives, the detection of signals where none existed, were committed far more often by the neurotic depressives than by the psychotic depressives or normal controls. Both depressed groups' vigilance deteriorated faster than did that of the normal controls, but only the comparison between psychotic depressives and normal controls reached statistical significance. The same reservation applies to this research as to Byrne (1976a) - classification of depressives into psychotic and neurotic groups introduced differences on other variables, e.g. age, genetic factors, and depressive severity.

Byrne (1977) himself later found that depressive severity was significantly related to vigilance deficits. However, he could find no evidence of a systematic relationship between depressive severity and the tendency to make false positive errors. Similar to Malone and Hemsley (1977), Byrne (1977) suggested that the tendency to make false positive errors may be more related to difficulties in controlling the output of motor responses than to deficits in the reception and processing of information.

Lister (1977) ignored the quantity of memories that he elicited from a group of depressed patients, as compared to a group of matched control subjects. These memories were elicited with a lengthy interview schedule, aimed at garnering memories from various categories of remote memory - personal, interpersonal, episodic; from different hedonic subtypes - pleasant, unpleasant; and from different periods - childhood, early adulthood, recent. A re-analysis of his raw data demonstrated that the control subjects remembered significantly more bits of separate information from long-term memory than did the depressed patients (critical ratio 3.19,  $p < .01$ ). Most of the depressive groups' 27% fewer memories were accounted for by the fact that they produced less elaborate pleasant memories. This finding could be attributed to any number of probable causes; it may have reflected their prior life experiences or it may have been due to their depressed state. However, one factor it could not be

attributed to was ECT, as none of them had ever received it.

Stromgren (1977) examined 152 patients with endogenous depression, rating both their level of depression and their memory functioning. A third of these patients were given tests of visual and verbal retention. She concluded that endogenous depression clearly impaired memory function as measured by the Wechsler Memory Scale and the retention tests. She also noted that the mental control sub-test, comprising tests of short-term concentration, serial addition and subtraction, etc., were slightly more sensitive to the effects of depression than the other sub-tests. Of the components of depression that were rated, agitation and depressive appearance bore significant relationships to memory decrements.

Malone and Hemsley (1977) assessed ten depressed patients on auditory signal detection before treatment and after remission. Their findings indicated both decreased movement responsiveness and decreased auditory sensitivity during depression. They attributed this latter deficit to an attentional disturbance. The average two-choice reaction time was 42% slower during depression than after remission. These deficits may have been underestimated, as these researchers excluded chronically depressed patients.

Kronfol, Hamsher, Digre and Waziri (1978), tested 18 moderately to severely depressed patients with neuropsychological tests which purported to sample left cerebral hemisphere functions (digit sequence learning, controlled word association, sentence repetition, token test of oral language comprehension) and right cerebral hemisphere functions (form sequence learning, judgement of line orientation, three dimensional construction, facial recognition). They found that the depressives' performance on the right hemisphere tests was more frequently in the defective range (i.e., performance exceeded by 96% to 98% of hospital control patients) than their performance on the left cerebral hemisphere tests. Two reservations should be mentioned concerning these findings. No neuropsychological test can ever justifiably be considered to tap only the functions of one cerebral hemisphere. Rather, some tests can best be described as having a predominant relative weighting in respect of one hemisphere over the other. This could reflect the differential ease of encoding into verbal or non-verbal mental representations of various types of material. Normally, due to the profuse intercommunications provided by the corpus callosum, both hemispheres work together interdependently. Even the most visual of material - random shapes, random dot patterns, or human faces - are readily encodable into verbal equivalents. Verbal encoding is probably prepotent normally (Williams, 1973). Alternately, the majority of language is laden with visual

imagery. These are not rare or little known phenomena; most people use dual-encoding quite naturally, without consciously thinking about it. There is another difference between verbal and non-verbal material that has been overlooked - differences in the level of difficulty between the two types of material. For example, the memory span for verbal material is nearly double that of the memory span for spatial locations; rehearsal of spatial locations is less effective than rehearsal of verbal material; and finally, the retention of spatial locations after learning is very unstable, whereas the retention of verbal material is moderately stable (Sanders, 1968; Christal, 1958; McGhie, Chapman, and Lawson, 1965). The auditory verbal memory store has been shown to be more efficient over time than the visual memory store (Margrain, 1967). What Kronfol et al (1978) probably have demonstrated is that depressed patients fare less well in proportion to the difficulty levels of the tests used.

There are three studies (Donnelly, Waldman, Murphy, Wyatt, and Goodwin, 1980; Donnelly, Dent, Murphy and Mignore, 1972; Savard, Rey, and Post, 1980) concerning the performance of depressed patients on the Halstead - Reitan Category Test. This test necessitates both the differentiation and integration of percepts. It consists of 208 trials involving four visual stimuli arranged in seven different series per trial. The subject should



note similarities and differences among the stimuli and through positive and negative reinforcement (bell or buzzer) arrive at an organising principle which could differentiate one stimulus from the other three. Discovery of the correct organising principle would then suggest correct answers throughout the series. All three studies consistently found that depressed patients made significantly more errors than non-patient control subjects. The study by Savard et al (1980) is particularly impressive in that the Spitzer Research Diagnostic criteria were used, and the patients ( $n = 26$ ) underwent an extensive medical workup including neurological examination, EEG, computed tomography, and lumbar puncture, all of which were within normal limits. More importantly, these patients had been treated in a unit which very rarely used ECT (Savard, personal communication).

Not only depressed mood can effect cognitive processes, but perhaps mood variability also can. Farber (1972) intensively studied the relationship between the kind and degree of mood variability in 36 female university students, and their performance on various memory tests. He was able to discern three fairly distinct groupings of these subjects: those with stable moods, those whose moods varied markedly in a single day, and those whose moods varied between different days. There were significant positive correlations between within-day mood variability and memory for childhood and personal



memories. Both the between-day and within-day mood variable subjects reported more often than mood-stable subjects that recall of the past could be painful and overwhelming. However, the between-day mood variable group contained a notable number of subjects who viewed their memories as unpleasant. Within-day mood variability was related to an episodic rather than an orderly, chronological method of relating personal memories. This type of mood variability was also related to a tendency to maximise affect when describing these events from remote memory. There was an inverse relationship between within-day mood variability and the recall of brief prose passages, particularly the recall of affect-laden passages.

In summary, there is strong evidence that depressive illness is associated with impairment of cognitive functioning. This impairment can include disturbances of attention, vigilance, the learning of new information, psychomotor speed, and memory. There is also evidence suggestive of a deficit in subjective time experience, auditory perception, and concept learning. There is weak evidence that suggests that clinical improvement of the depressive state does not necessarily lead to improvement in cognitive functioning, and that this occurs more frequently amongst older bi-polar patients (Perris, 1966; Friedman, Culver, and Ferrell, 1977; Savard, Rey, and Post, 1980). However, many of the papers exclusively

concerned with cognitive function in depression do not provide any information about the patients' life-time exposure to ECT, to psychotropic medication, to large overdoses, or to other factors which may have had effects upon cognitive functioning.

Literature ReviewChapter TwoThe Effects of Electro-convulsive Stimulation (ECS) on the Performance of Laboratory Animals.

Much of the research on the effects of electro-convulsive stimulation (ECS) on animals has focused on the readily demonstrable retrograde amnesia (Duncan, 1949; De Vietti and Larson, 1971; Hayes, 1948; Heriot and Coleman, 1962; Herz and Peeke, 1968; Kopp, Bohdaneykc and Jarvic, 1966; Leukel, 1957; Madsen and McGaugh, 1961; Stainbrook, 1948; Suboski, Spevack, Litner and Beaumaster, 1969; Thompson and Grossman, 1972; Thompson and Dean, 1955; Zornetzer, Chronister, and Bart, 1973).

The objective of most of this work was not to elucidate the factors related to the induction of an electrical convulsion as a treatment per se. Rather these researchers' primary aim was to understand various hypothetical memory processes, e.g. state dependent learning, consolidation, retention, fixation, retrieval, etc., and they simply used ECS as a convenient disruptor of these processes. Although usually rodents were studied, anthropomorphic inference was rife. The greater degree of experimental control that could have been exerted in such work was balanced by the many reservations needed to generalise these findings to the human experience.

However, the studies which looked specifically at the after-effects of ECS, at the possibility of a lasting anterograde amnesia, have shown such effects to be reversible.

There are five studies bearing on the effects of ECS on psychomotor activity. Siegel (1943) found that a course of ten (10) daily electroconvulsive shocks produced a slight slowing in the speed it took mature albino rats to traverse a thirty (30) inch runway. Only three days after the shocks, the rats had returned to normal speeds in comparison to a non-shocked control group, and subsequently surpassed them, becoming on average five seconds faster.

Stone (1946), giving his animals 15 ECS on an unrealistic schedule of 5 daily ECS separated by 5 days without ECS for three alternating periods, found that this procedure produced a reduction of the animals' activity in a revolving drum apparatus, but only for a short period of time. The major changes appeared within the day after the last ECS was administered. Within two weeks after the last ECS the majority of animals closely approximated to their pre-shock levels of activity.

Siegel, McGinnies and Box (1949), found that a single ECS produced no disturbance in the running behaviour of mature male albino rats (Sherman strain, 15% underweight) as tested 8.5 hours after the ECS. In addition, an experimental subgroup given an injection of saline solution rather than general anesthesia (nembutal) had a significantly slower running time at the post-ECS testing.

Stern (1956) found an increase in wheel-turning following courses of 16 daily ECS, as measured up to 34 days after the last ECS, but no significant increase after only 6 daily ECS, as measured up to 44 days after the last ECS. Open field activity was significantly decreased for the rats receiving either 6 ECS or 16 ECS as compared to non-ECS controls. For this measure of activity there were no significant differences between the 6 ECS and 16 ECS groups. These rats remained in the middle of the open field, near to where they were placed, without giving much indication of the usual "exploratory behaviour" otherwise exhibited. Stern, however, may have misinterpreted the open field activity of the control rats, which he termed "exploratory behaviour". Rats usually are active in an open field, but not because they are exploring it; rather, this particular situation has usually been seen as fear-provoking for nocturnal rodents, and has been used as a measure of the rat's hypothetical "emotionality". (Eysenck, 1965). Stern's findings are further contradicted by the better-controlled study of Nielson (1968), who found that ECS increased open field activity.

In the areas of putative memory and learning processes, researchers have set up various behavioural indices which, it was hoped, would have reflected such processes. Their ingenuity has run the gamut from double-alternation lever pressing (McGinnies and Schlosberg 1945) through light

discrimination learning (Horowitz and Stone, 1947), complex maze performance (Braun, Russell and Patton 1949; Russell, 1949; Broadhurst, Stone and Lawrence, 1952; Murphree and Peters, 1956), avoidance learning (Zinkin and Miller, 1967; Nielson, 1968; DeVietti and Bucy, 1975) and visual pattern discrimination learning (Brown and Simpson, 1956; Williams, 1959) to discrimination - reversal learning (Braun, Barnes, and Patton, 1957). Regardless of the specific experimental variable devised to show behavioural change, it is highly significant that all of these studies showed recovery to former normal levels after ECS. Recovery took from one day to twenty four days, depending largely on the number of shocks delivered, task difficulty (Russell, 1949; Williams, 1960), and concomitant ECS - produced increases in activity levels and temporary decreases in brain excitability levels (Nielson, 1968).

McGinnies and Schlosberg (1945) selected double alternation lever-pressing because it was a difficult habit and therefore would be a sensitive indicator of any effects ECS might have had. They only studied four (4) mature male rats in what were essentially repeated single case designs. These rats received between 14 and 19 bi-weekly shocks, but afterwards performed at their pre-ECS level or better, even on the days following ECS.

Horowitz and Stone (1947) trained mature Wistar-Slonaker

albino rats for 19 days on a light-discrimination habit, then divided them into an experimental group (n=13) and a control group (n=10). The experimental group received 15 daily electroconvulsive shocks and 10 pseudo-shocks. The control group received 25 daily pseudo-shocks. After this the experimental group approached, but did not quite reach their former level, or that of the control group, but the authors stated: "Our data suggest that, given sufficient time, full recovery from the deleterious effects of 15 convulsive shocks .... will take place in the albino rat".

At first reading, particularly to someone not versed in animal research methods as applied to ECS, the research by Braun, Russell and Patton (1949) could suggest that a series of electric convulsions is permanently, though only slightly, damaging. Their research design was poorly conceived, primarily because it attempted to answer questions concerning retrograde amnesia, anterograde amnesia, learning ability, and retention on a single experimental series. Any one of these issues is sufficiently complex to warrant a major experiment apiece. Studied together, their individual causes and effects are hard to disentangle in experiments with animals.

The retrograde amnesic effects are unquestionably real, although a minority opinion concerning their permanence has been broached and backed up by good experimental

evidence (Zinkin and Miller, 1967). Usually, this retrograde amnesia is persistent and highly stable (Zornetzer and McGaugh 1969) but "patchy" (Robustelli, Geller and Jarvik, 1968), and the extent of it is closely related to details of the experiment (e.g. stimulus duration, stimulus-ECS interval, transcorneal vs. ear electrodes, electric current used, etc.).

Despite reservations about the way in which Braun et al (1949) confounded retrograde amnesic, confusional and anterograde amnesic effects, these researchers were able to show in a subsidiary experiment that retention of a spatial maze-swimming sequence learned after a series of 25 daily ECS was almost perfect. The post-ECS learning group's retentive capability was also significantly better, in terms of trials to learning criterion, errors or time, than a group that learned the maze before ECS.

Brown and Wilbanks (1952) fell into similar traps to Braun et al (1949), and further confused the issue by inadvertently aversively conditioning their animals by placing them in the problem maze immediately after each convulsion. Brown and De La Garza (1953) repeated this mistake, but also provided a description which holds the key to understanding their error. After placing a rat into a maze on the day following the completion of 20 daily ECS they note, ".... it was not uncommon for an animal to fail to negotiate a turn or fall to the



floor. When these animals were placed at the starting point on the maze, it was not uncommon for them to urinate and/or defecate. This behaviour was also observed at other points along the maze whenever the animal had unduly lengthened the distance and the time from the starting point to the food box by entering an excessive number of cul-de-sacs and had made several retraces". Despite the maze having undoubtedly become an aversive stimulus, the rats ( $n=10$ ) were able to reduce their running time to the goal from 540 seconds to 40 seconds by the eighth day after the ECS period. This time is only 15 seconds slower than the non-ECS control rats. This experiment was subsequently broken off without a longer-term followup. The work of Carson (1957) had similar methodological deficits.

Broadhurst, Stone and Lawrence (1952) randomly allocated 70 Wistar strain rats into four groups, one group receiving epanutin and 12 daily ECS, a second receiving a placebo and 12 daily ECS, a third group receiving epanutin and pseudo-shock, and a fourth group receiving placebo and pseudo-shock. The experimental task in this study was a difficult multiple choice-point water-filled maze. At 12 days post-ECS, when observations were terminated, there was a mean difference of only 0.5 error between the shock and non-shock groups.

Murphree and Peters (1956) compared groups of rats

receiving ECS or insulin coma treatments with control rats on a complex 14 choice-point maze. There were no significant differences between the learning curves of these groups.

Neilson (1968) trained groups of rats to inhibit a response of stepping off a platform. When activity levels and brain excitability levels were equalized, ECS did not produce even a transient disruption of this avoidance response. This finding is similar to that of Zinkin and Miller (1967), which demonstrated that avoidance learning conditioned on a single occasion is susceptible to a significant amnesic effect only at 24 hours post-ECS. However, this amnesia largely disappears in further retention tests 48 and 72 hours after ECS. Nielson (1968) concluded from his experiments that ECS does not disrupt memory fixation, which is dependent upon a neural reverberation process. He further hypothesized that memory retrieval may be temporarily altered by ECS, by its transient effects on brain excitability. His hypothesis, which was a forerunner to state-dependent learning, predicts that failure of retention will occur whenever brain excitability is modified away from that established during training. Evidence favouring this dissociation hypothesis was subsequently obtained in a series of experiments by De Vietti and Bucy (1975).

Brown and Simpson (1956) set up an experimental situation

that involved the discrimination learning of visual patterns. Twelve daily ECS produced no significant differences between the experimental and control groups on easy and difficult discriminations. However, in this study there was no followup beyond 24 hours. Nevertheless, this study demonstrates that there is no appreciable loss in visual learning if learning is allowed to proceed during the ECS course with a period of nearly 24 hours between each shock and the next learning trial. This is sufficient time for the disruptive effect of the preceding shock to have subsided.

Finally, all the above research has been conducted on rodents. Such animals were obviously operating at a relatively primitive level cognitively, so much so that extrinsic motivational factors needed to be manipulated in order for the animals to acquire and maintain a habit. Such extrinsic factors were partial food deprivation, aversive electric shock, escape from water, etc. Moving up the phylogenic hierarchy may uncover differences in the subtlety of the learning process so great as to make them qualitatively distinct from those demonstrated in rats. Only one such study has been attempted to date: Braun, Barnes and Patton (1957) showed that a series of 20 ECS failed to disturb the discrimination learning sets of monkeys.

There are several substantial problems in generalising

any of the above studies to the effect of ECT on humans. Already mentioned are the gross anatomical inter-species differences. Not all of the researchers used anaesthetics or muscle relaxants, nor is it possible to say whether the intervals between ECS applications have equivalent effects across species. The electrical current dosages applied in most of the rodent research were enormously large (estimated to be 12 - 50 times higher) in relation to the weight of the brain as compared to the dosages used in human ECT. The Joule-heat generated in the animal experiments was considerably larger (Heshe, Roder, and Theilgaard, 1978). But perhaps most important is the circumstance which is consistently not paralleled at all, that having to do with psycho-pathological phenomena. None of the animal experiments were conducted on animals that had first been "depressed" for a significant length of time, though some were temporarily frightened. Although it has been possible for some time to create approximate behavioural analogues of depression, or at least apathy, there is no way of knowing if such analogues in animals are qualitatively similar. The assumption that the apathetic behaviour of laboratory rats is a useful model of human manic-depressive psychosis may be incorrect.

Chapter 3. The effects of psychotropic medication on human cognitive function.

Whether or not psychotropic medications have any significant cognitive sequelae is not as contentious a topic as are the side-effects of ECT. However, psychotropic medications should command at least as much attention, due to their more widespread prescription. To date, if one regards only psychometric research on patients repeatedly tested before, during, and after the administration of these medications, the quality and applicability of this research is probably inferior to comparable ECT research.

A majority of researchers have found that tricyclic antidepressants do not impair cognitive functions. Straand (1962) found no impairment of intellectual function on psychological tests, even with maximum dosages of imipramine, although subjective complaints of absent-mindedness occurred with dosages of 125 mg daily or more. Friedman, Granick, Cohen, and Cowitz (1966) in their comparison of the drug (200 mg daily) to placebo for three weeks, found no significant performance advantages or deficits related to imipramine on 22 psychometric tests. The subjects in this randomized, double-blind trial were hospitalized psychotic depressives. Henry, Weingartner, and Murphy (1973) found that imipramine had no effect on either serial or free recall.

Weiss, Robinson, and Dasberg (1973), using two memory tests of demonstrated sensitivity, could find no evidence of memory change attributable to antidepressant medication. This was a well-designed study; the patients were sufficiently depressed to warrant hospitalization and were tested before treatment, at one and at two months after the treatment began. Liljequist, Linnoila, and Mattila (1974), in a double-blind study using 20 male students as subjects, found that two weeks administration of chlorimipramine (at no more than 75 mg daily) had no measurable effect on learning and short-term memory. Sternberg and Jarvik (1976) compared 20 depressed patients who had recovered after a month's antidepressant treatment to non-patient controls equated for sex, education, and age. The patients were all first admissions, and had never received ECT or antidepressants. All of the patients showed improvement in cognitive function; this was related to the alleviation of their depressive symptoms. Kusumo and Vaughan (1977) showed that tricyclic antidepressants impaired recall after a 15-second interval in depressed patients relative to normal controls. However, the patient sample in this study was very small ( $n=6$ ). However, Legg and Stiff (1976) presented evidence that high doses of imipramine (275 mg daily) impaired the ability to learn and retain information after a three week treatment period.

An equal number of researches have shown that lithium

salts impair aspects of cognitive function as have those showing it does not. Bech, Thomsen, and Rafaelson (1976) found significant decrements on simulated driving tests and psychological tests after long-term lithium treatment. Judd, Hubbard, Janowsky, Huey, and Takahashi (1977) found deficits on three out of five performance tests. The subjects were 24 normal males compared after 2 weeks of placebo and 2 weeks of lithium in a crossover, double-blind design. The deficits were ascribed to a slowing (by about 10%) of motor execution rather than any slowing of internal information processing. Kusumo and Vaughan (1977) studied 13 patients with diagnosed affective disorders, who had been taking lithium for 3 months to 4 years, compared to drug-free controls. The patients on lithium were impaired on short-term recall, but also showed enhanced long-term recall of difficult material. Oerlinghausen, Bauer, Girke, Kanoski, and Concalves (1977) reported an impairment of vigilance and psychomotor performance both in patients and in volunteers under lithium treatment.

On the other hand, Henry et al (1973) and Telford and Worrall (1978) could find no objective support for a lithium-related cognitive impairment. Koran and Maxim (1972) examined field dependency in 16 symptomatic manic-depressives while they were drug-free. Serial measurements were repeated when these patients were symptom-free on lithium or placebo. Field dependency was unaffected

by clinical state or lithium; the score distributions of the patients resembled those of volunteers. Pfeiffer and Maltzman (1976) found that manic-depressives ( $n=36$ ) were uniformly slower than controls ( $n=20$ ) at reaction time tasks at all pre-signal warning intervals (1, 2, 4, 8, and 16 seconds). Lithium facilitated reaction times, particularly at the longer intervals and under an irregular-series presentation condition.

Research into the side-effects of minor tranquillisers on performance was roundly criticized by McNair (1973) on the grounds of poor methodology, gaps in the data base, and a lack of clinical relevance. In the studies that he reviewed, when one of the benzodiazepines were administered, significant impairment occurred five times as often as facilitation. Performance decrement was twice as often associated with diazepam than chlordiazepoxide. Significant performance effects had been obtained at nearly the same rates in studies of patients and non-patients, though these two types of studies were not strictly comparable.

Work in this field has continued to reveal the cognitive side-effects related to the use of diazepam. Uhlenhuth, Turner, Purchatzke and Chassan (1977) studied the effects of diazepam (5 mg three times a day) in eleven anxious patients. The patients were treated double-blind for 8 weeks. In each of four 2-week blocks, the patient



received diazepam one week and placebo on the other week. A reliable diazepam-produced effect was a significant slowing of reaction times at two, four, and eight weeks after the trial began. Jones, Lewis, and Spriggs (1978) found that diazepam produced a significant deficit in visual search ability and an adverse effect on short-term memory, with no effect on vigilance or mental arithmetic. Hendler, Cimini, Ma and Long (1980) compared 13 new pain clinic patients who had been taking benzodiazepines chronically to 13 similar patients taking narcotic agents chronically. They found that the former group evidenced significantly more psychometric signs of cognitive impairment and had significantly more abnormal EEG patterns.

Many of the published studies on the side-effects of hypnotics are unsatisfactory. Many have reported on only about six subjects, often much younger than those to whom they are usually prescribed, and often after only a single dose instead of sustained intake. However, there is consistent evidence that flurazepam significantly impairs psychomotor speed (Church and Johnstone, 1979; Vogel, Barker, Gibbons, and Thurmond, 1976; Borland and Nicholson, 1975; Broadhurst and Arenillas, 1975; Salkind and Silverstone, 1975; Bixler, Kales, Tan, and Kales, 1973; Bond and Lader, 1973) and auditory vigilance (Oswald, Adam, Borrow, and Idzikowski, 1979). There is less compelling evidence that nitrazepam has subtle impairing effects on short-term memory (Peck, Adams, Bye,

and Wilkinson, 1976; Adams, 1974), but does not affect concentration after three weeks' use.

It should be noted that few of the subjects in the benzo-diazepine studies were clinically depressed, and that the periods of prospective research observations were shorter than many recovering or chronic depressives use such medications. It is possible that some patients could adapt to some of the abovenoted side-effects.

Only two researches have examined the cognitive effects of the major tranquillisers on depressed patients. Motz (1955) tested a group of psychotic patients suffering from affective disorders. He administered equivalent forms of the Wechsler Adult Intelligence Scale and Wechsler Memory Scale to these patients before treatment began, in mid-treatment (which coincided with the point when the patients' drug dosages were at their maximum level), and at discharge. Test order was counterbalanced. All patients received "massive" doses of chlorpromazine. The depressive patients did not show any cognitive improvement whatever on this medication, even when the drug was having its most potent effect on these patients' symptoms.

Legg and Stiff (1976) randomly allocated 49 hospitalized depressed patients to treatment for three weeks with chlorpromazine (average daily dose 550 mg), or imipramine

(average daily dose 275 mg), or similar quantities of placebo. Testing was performed double-blind using the Wechsler Adult Intelligence Scale, Benton Visual Retention Test, Wechsler Memory Scale, and reaction time tests in both the visual and auditory modalities. The researchers found that chlorpromazine impaired the sustained attention of depressed patients. Placebo-treated control patients made greater improvements between the pre-treatment testing and testing at three weeks on three performance sub-tests of the intelligence scale (Digit Symbol, Block Design, and Picture Completion) than did the patients on chlorpromazine. In addition, the chlorpromazine group was significantly impaired on the visual reaction time test. Therefore, an alternative reading of these results is that chlorpromazine has particular detrimental effects on the visual information-processing speed of depressed patients.

To summarize, tricyclic antidepressants in therapeutic doses do not appear to cause any detectable cognitive dysfunction, except perhaps at rather high doses. Most of the studies to date have been on imipramine; the dearth of relevant data on amitriptyline is regrettable in light of its not uncommon use. The evidence on lithium is equivocal; its sedative properties could account for some slowing of psychomotor responses, but there may also be cognitive facilitation in patients with bipolar affective disorders and perhaps some unipolar patients

under some circumstances. There is a weak suggestion that longer-term lithium use may be associated with more discernible performance deficits. As to the benzodiazepines, diazepam and flurazepam unquestionably do cause genuine cognitive and psychomotor sequelae amongst non-patients and patients suffering from anxiety or insomnia. However, there have not been any studies of the cognitive side-effects of benzodiazepines on clinically depressed patients. Chlorpromazine does interfere with the cognitive processes of depressed patients, but major tranquillisers usually are only administered in significant doses during the acute phase of a depressive breakdown. Overall, there is abundant evidence to warrant the cautious control and observation of concomitant psychotropic drug side-effects in a study of the side-effects of ECT.

Chapter Four. Literature ReviewThe Effects of Electroconvulsive Therapy on Human  
Cognitive FunctioningA) The effects of ECT on visual perception.

Brower and Oppenheim (1951) tested the visual perception of 35 hospitalized cases of psychotic depression (mean age 50, range 26-61) both before and one week after ECT. Their visual perception was significantly improved after treatment.

De Bousingen (1951) studied the stereoscopic acuity of 5 patients before, during, and after a single course of ECT. He noted a distinct improvement in this ability, particularly in the three hours following each treatment. Ten days after ECT each individual had returned to his normal level of acuity, if not slightly improved.

Damiani (1956) studied light sensitivity and visual field effects in 9 patients before and after ECT. All of these patients showed an improvement in sensitivity, whether absolute luminal values or adaptation values were measured. The visual field tests in all cases showed widening at the periphery. Damiani (1956) interpreted these effects to be due to stimulation of oculo-diencephalic regulation mechanisms by ECT.

Arai and Obonai (1957) administered eighteen tests of varying validity to 64 patients before and after a single

ECT. They presented their results in terms of the recovery time(s) required post-treatment to return to the pre-treatment level, none of which exceeded 45 minutes.

Although these four researches uniformly found no evidence of ECT-related perceptual defects, they also uniformly had no control groups. Numbers in the middle two studies were small. The question of how much improvement was due to the relief of depression, and how much to hypothetical stimulatory effects of ECT, was unanswered; no ratings of depression were attempted. Impaired concentration can cause careless mistakes to be made in analyzing and reporting perceptions. Minimal difficulties in visual perception also need to be taken into account when visuo-spatial memory is studied. Very few of those who have published in this field have considered this variable.

B) The effects of ECT on psychomotor functions.

Deri (1947) studied the psychomotor speed of 19 in-patients with depressive symptoms who were given ECT. This researcher also used two control groups, one consisting of ten in-patients with depressive symptoms who were not given ECT, the other consisting of ten hospital employees. Deri (1947) reported that patients after ECT became motorically less inhibited, but he did not mention whether this change was related to clinical improvement. Many of the tests he employed were of the projective type, and of low validity and reliability.

Fisher (1949) studied the speed of verbal associative processes in 57 depressed outpatients who received ECT. These patients were male military veterans (mean age 29, range 19 - 45). Their word association response times were measured before treatment and one month after treatment. No decrements were noted. However, practice effects were not excluded, and there was no control group. There was a significant relationship between clinical improvement and faster reaction times, which possibly could have masked a decrement in reaction times produced by the treatment.

Brower and Oppenheim (1951), who tested 35 psychotic depressives before and one week after ECT, reported "vastly improved" visuo-motor coordination, both under neutral conditions and under an experimental condition of visuo-motor conflict. They also noted an increase in psychomotor speed, which they interpreted as due to "heightened activity of the motor discharge channels". However, the patients found their movements more difficult to control after initiating them than they had before ECT.

Hetherington (1952) examined hand-eye coordination (as measured by a Track Tracer). Although the experimental group tested before, during, and up to two weeks after ECT, was small ( $n=10$ ), there were two control groups, one consisting of ten nurses and the other of fifty male ARP workers. A significant fall-off in efficiency in the ECT

group was ascertained at followup, to 58% below the level of the control groups.

Callaghan (1952), who noted that ECT had a temporary adverse effect on manual dexterity, compared 25 depressed patients before and after ECT to 25 depressed patients who were hospitalized for one month but did not receive any specific treatment. The ECT group one week after treatment made fewer errors on a Track Tracer instrument than the control group did. The former group had apparently opted for accuracy rather than speed. Four weeks later, the ECT group tended to give more consideration to speed than to accuracy.

Campbell (1957) took steps to correct several of the methodological flaws in Hetherington's (1952) research. He randomly divided a group of 30 depressed patients into two groups, one that received ECT, and one that did not. Both groups showed improved psychomotor speed at followup, but the incidence of no improvement in psychomotor speed was greater in the ECT group, despite this group's improvement in mental state. The amount of psychomotor improvement shown by the control group was proportional to their initial slowness. The ECT group improved their psychomotor speed also, but an alleged ECT side-effect was a reduction in this improvement. However, this study only investigated the more immediate effects of ECT; long-term followups were not attempted. Shapiro, Campbell,



Harris, and Dewsbery (1958) replicated Campbell's (1957) design and findings; however, their final testing was performed only 3 to 8 days post-treatment.

Goldstein, Filskov, Weaver, and Ives (1977), attempted to follow-up 20 patients who had been tested one day prior to treatment and one day after treatment. However, at follow-up three months post-ECT, only half of the original sample made themselves available. Nevertheless, there were statistically significant improvements on two measures of motor speed - finger tapping with the preferred and non-preferred hand. However, these results were tentative because of the high drop-out rate, and confounded because half the patients received traditional bilateral ECT and the other half received low-energy brief-stimulus ECT.

In summary, there are no definitive research studies on the long-term effects of ECT on psychomotor functions. The longest followups were one month and three months, and neither of these studies measured depressive severity. The likelihood of relapse or residual depression was not considered. Global measures of psychomotor speed, such as the ones employed by Hetherington (1952), Callaghan (1952), Campbell (1957), and Shapiro et al (1958), are unable to discriminate slowed central processes from slowed motor action. There was some evidence that there may be short-term effects on psychomotor function



associated with ECT, lasting at least a week after treatment. Whether these sequelae are more enduring, or specific to ECT patients, cannot be determined from the existing literature.

C) The effects of ECT on learning.

Huston and Strother (1948) administered verbal learning tests to 75 patients (mean age 41, s.d. 13) with affective disorders, prior to ECT, eleven days after treatment, and six months after treatment. Thirty per cent of the sample were lost to the long-term followup. These researchers also tested, at equivalent intervals, 17 normal controls matched for age, vocabulary level, and "mental efficiency". At the eleven day post-ECT follow-up there was a slight, nonsignificant improvement in verbal paired-associate learning. When the same test was administered six months later, there was a relatively greater, statistically significant improvement. Although Huston and Strother (1948) used the same test on each occasion, they were anxious to minimize practice effects. They presented non-significant correlations between number of days between testing occasions and change scores as evidence of small practice effects. This may not have been correct, as number of repetitions of the same material, and corresponding familiarity, may be a more important determinant than the passage of time. An unnecessary source of variability in this study was the wide differences in the final followup interval (e.g., s.d. 99 days, range 36-570 days).

Korin, Fink, and Kwalwasser (1956) found that the ability to learn common words had returned to pretreatment levels or better within 3 weeks after ECT. However, one fourth of their patients were schizophrenic, and there was no control group.

Brengelmann(1959) studied two groups of depressed patients before, during and three weeks after ECT. In the experiment with the first group (n=40), a simple visual learning test of spatial relationships was administered on 16 occasions. Practice effects were controlled by the use of 16 parallel test versions; three were given on the day preceding treatment to further reduce practice effects. Serial order effects were eliminated by rotating successive patients at different points in the test series. The mean number of errors decreased from 26 errors for the pre-treatment tests to 7 errors three weeks after ECT. On this test occasion, six patients (15%) showed learning impairment. In the experiment with the second group (n=30), which was equivalent to the first group on age, intelligence, and spacing of treatments, much more difficult test stimuli were administered on 8 occasions. The mean number of errors decreased from 123 errors pre-treatment to 65 errors three weeks after ECT. The interscorer reliability coefficient of the tests exceeded 0.99. No data were presented concerning inter-test reliability or performance on the tests by non-patients.

Kendrick and Post (1967) used parallel tests in their comparisons of forty elderly depressed patients (mean age = 70, s.d. 6.3 years) who were randomly assigned to either a course of 8 bilateral ECTs or treatment with imipramine for three months. Both groups were equivalent on age, education level, social class, and verbal intelligence. The patients in the ECT group received no medication during or following treatment. The patients in the imipramine group received dosages up to their individual maximum tolerance level. The learning tests used, Synonym Learning and the Inglis Paired Associate Learning Test, have no significant practice effects; parallel forms of these tests are equivalent. This was substantiated by analysis of variance, which demonstrated an absence of group by testing occasion interaction.

Kendrick and Post (1967) concluded that when elderly depressed patients responded to either ECT or imipramine, or at least became no worse clinically, no differences on verbal learning could be demonstrated. No deleterious effects of ECT could be demonstrated when patients learned new material either 24 hours or several months after treatment. Imipramine likewise had no deleterious effects nor any superiority over ECT in regard to effects on verbal learning.

Hemsi, Whitehead, and Post (1968) tested 68 depressed elderly patients (mean age 69, s.d. 5.7) with the Synonym

Learning Test. Initial testing was within several days of admission. This group were moderately depressed (mean 25, s.d. 6) on the Hamilton Depression Rating Scale. All these patients subsequently received ECT, and were re-tested two weeks after the course. The Hamilton Rating Scale level had decreased to a mean score of 3.4 (s.d. 2.3). There was also improvement on the learning test, although variable and not statistically significant. However those elderly depressives who had initially scored within the 'demented' range on testing (about one sixth of this sample), only occasionally rose above that level following remission two weeks after ECT.

Miller (1970) examined verbal learning in depressed patients prior to treatment (consisting of 6 bilateral ECTs), 0.5 hours before the sixth ECT and 2.5 hours, 5 days (range 3-6 days), and 9 days (range 7-14 days) following treatment. Parallel tests, a counterbalanced design, and a well-matched patient control group made this one of the more methodologically sophisticated studies. The effects of depressive illness were confirmed, as were the immediate post-treatment (30 minutes after the sixth treatment) effects of ECT on verbal learning. No learning deficits were revealed at either 5 days or 9 days post-ECT.

#### D.) The effects of ECT on memory

The first reports concerning the effects of ECT on memory

were accumulated clinical observations. Furst and Stouffer (1941) mentioned that there was a transient, patchy loss of memory lasting a few weeks to no longer than two months, that returned in a patchy fashion. Hemphill and Walter (1941) noted that a proportion of patients noticed a slight defect of memory for details and recent events during the entire course of ECT. This particularly showed itself in the inability to remember names or where objects had been placed, and some patients were disorientated for time, but these effects in every case disappeared completely after the treatment. Kalinowsky, Bigelow, and Brikates (1941) attested that there were transient impairments of memory related to ECT, that these effects "occasionally" lasted a few weeks, but usually cleared up shortly after the treatment.

Levy, Serota, and Grinker (1942) studied 23 patients with "affective reactions", 12 of whom received ECT and 11 in whom the therapeutic convulsions were produced by metrazol. Changes in general intellectual function were noted in 45% of the cases. Recovery of memory occurred usually in a few weeks, but in more severely effected patients memory impairment sometimes lasted six months. Separate analyses were not undertaken for the different treatment forms.

Smith, Hughes, Hastings, and Alpers (1942) stated that they had seen no ECT patients in whom memory defects had

been permanent. In a subsequent article, Smith, Hastings, and Hughes (1943) reviewed 187 depressed patients that they had treated with ECT. All of these patients had some degree of memory difficulty, ranging in duration from a few hours to nine months. Duration of deficient memory increased with the number of treatments and with the age of the patient. There was no relationship between age and the degree of memory impairment.

Delay and Binois (1944) compared 23 patients who received ECT to 12 patients who received no treatment. Attention, as indicated by repeated cancellation tests, improved whether the patients received ECT or no treatment. Recovery of memory in the ECT patients occurred 8 to 15 days after treatment.

In the above seven papers, which are mainly dependant on the unsubstantiated reports of patients and on clinical estimates of memory functioning, the variability of the recovery times exceeds the average recovery time. This raises the possibility of unreliability, or the influence of extrinsic factors, such as the feasible length of followup.

Hobson's (1951) dissertation, on factors predicting a good response to ECT, was an important watershed in the study of ECT-related effects. It was a large-scale collection of case history material, but was more systematic than

the preceding work. It was also one of the earliest studies to use objective memory testing, though only partially, i.e., for five patients who complained of persisting memory difficulties. An objectively determined memory impairment was established (retrospectively) in only one of these patients. This could have been a low estimate. Many of the 177 patients were under the clinical care and responsibility of the researcher; because they may have felt thankful to him for relieving their illness, some may have avoided mentioning an annoying but not overwhelming side effect. Some may have hidden their cognitive inadequacies, perhaps to avoid further hospitalization.

The next phase of research into ECT side-effects used standardized psychometric tests fully throughout each investigation. There was a tendency to use ECT patients as their own controls; in some cases test data could be compared to published norms. The Wechsler Memory Scale (WMS), an instrument not without its critics (e.g., Prigatano, 1977), was usually chosen for the assessments.

Stone (1946) assessed two groups of patients. Group 1 received the WMS, Form I, one day before ECT and Form II one day after the final treatment. Group 2 received the WMS, Form I, one day after the final treatment and Form II, two weeks later. Each group numbered 15 patients. Group 1 showed a statistically significant loss of 16% from



their original score, and Group 2 showed a statistically significant gain of 27% from their initial score, indicating improvement.

Janis (1950) found amnesias for personal remote memories in psychotic patients (n=19) four weeks after ECT. This researcher used scrupulous interview schedules and a prospective design that included a control group. However, the ECT group received more treatments per course (mean = 17, range 8-27) than is usual nowadays (e.g., Freeman and Kendall, 1980), and more frequently, at a rate of three treatments per week.

Brower and Oppenheim (1951) tested 35 in-patients with psychotic depression (mean age 50 years) with a visual retention test and an auditory digit-span test. Using two parallel forms of the retention test, 31% of the patients showed improvement at one week after treatment. The digit-span test showed slight improvement.

Stenbäck, Viitamäki, and Kukkonen (1957), tested 37 "mixed psychotics" who were randomly allocated to ECT administered twice a week (n=21), or to ECT administered in "blocks" on three successive days (n=16). The Wechsler Memory Scale was used. Both groups improved on all the WMS sub-tests, when test data from before treatment was compared with data obtained one week after ECT. The improvement in cognitive function was greater in the

block treatment group than in the twice-weekly treatment group, with the exception of the digit-span sub-test. The patients were given identical test material on both occasions, therefore practice effects cannot be discounted. No measures of dispersion were published, nor were inferential statistical tests performed.

Cronholm and Molander (1964) tested 28 patients (mean age 43, range 24-69) with "relatively mild mental disturbances". Ten were diagnosed as neurotic. Testing was conducted one day before and one month after ECT. These patients received a mean of 5.3 treatments over an 18-day period. Three memory tests, the 30-Word-Pair Test, the 30-Figure Test and the 30-Personal Data Test, were used. In all three tests, reproduction was requested immediately after learning and three hours later; the difference between immediate and delayed reproduction was denoted as "forgetting". In none of the measures used was any decline found a month after treatment. An improvement was found in immediate reproduction, which the researchers attributed to improvement in the patients' emotional state.

Miller (1970), examined the "savings" in verbal re-learning three hours after initial learning, and thus could make inferences concerning the state of his subjects' memory capabilities. He could find no evidence of impairment in verbal memory at 5 days (range 3-6 days) or 9 days (range 7-14 days) post-ECT in a group of 20 patients who

had received 6 bilateral ECTs, as compared to a control group. This comparison group was matched to the ECT group on age, sex, diagnosis and Wechsler Verbal Intelligence Quotient, but had not received ECT.

In an exemplary piece of research which deliberately fixed the number of ECTs and eliminated all concurrent psychotropic medication, Turek and Block (1974) tested 30 depressed patients (mean age 42, range 23-60 years). Analysis revealed, at the 1% significance level, that Wechsler Memory Scale Memory Quotients (MQs) declined up to the final treatment, and then rose almost to the pretreatment level within a week. Pretreatment MQs did not differ by age or sex; nor could initial MQs be used as predictors of eventual therapeutic improvement. At the test one week following ECT there were no differences between those patients who improved clinically and those regarded as treatment failures.

Few of the above studies utilized comparable control groups. This was ethically necessary before the introduction of anti-depressant medication, when there was no alternative to ECT other than a needless, sometimes hazardous, delay. Even after the advent of antidepressants, many psychiatrists preferred ECT for the treatment of certain types of depression. One partial solution to the control group problem was the comparison of groups that received either bilateral ECT or unilateral ECT.

Martin, Ford, McDonald, and Towler, (1965), randomly assigned 40 depressed patients to either a course of 10 bilateral or 10 unilateral treatments. Depressive symptoms were alleviated to an equivalent degree by both ECT configurations. Parallel forms of the Wechsler Memory Scale were administered before the first treatment and 24 hours after the final treatment. Whereas the unilateral ECT group showed a statistically non-significant improvement in memory, the bilateral ECT group showed a statistically significant decrement in memory. Although this study was not concerned with enduring sequelae, it does demonstrate the relative innocuousness of unilateral ECT. This study was approximately replicated by Sutherland, Oliver, and Knight (1969), who did not use parallel versions of the Wechsler Memory Scale, and who also treated and tested a more heterogeneous patient sample.

Halliday, Davison, Browne, and Kreeger (1968) randomly assigned 44 patients to one of three treatment groups: unilateral ECT to the right cerebral hemisphere, unilateral ECT to the left cerebral hemisphere, or bilateral ECT. The tests employed were a verbal learning test, i.e., learning, and remembering, the meanings of 5 unfamiliar words; a digit span test; and a non-verbal learning test, i.e., learning, and remembering, the Rey-Davis pegboards. At three months after treatment, the group receiving unilateral ECT to the dominant cerebral hemis-

phere was significantly impaired on the verbal learning test relative to the unilateral non-dominant ECT group. The dominant unilateral ECT group's pre-treatment non-verbal memory impairment disappeared, while that of the bilateral ECT group persisted. The bilateral ECT group were more impaired than either of the other groups, but only one of the group differences was statistically significant (viz., the bilateral ECT group was more impaired than the non-dominant unilateral ECT group on the delayed non-verbal test).

There were critical flaws in the Halliday et al (1968) study. Chief among these was that there was no statistical consideration or experimental control over further ECT or psychotropic medication between the post-ECT testing and the three-month followup testing. The differential drop-out rate between the groups was statistically significant. One of the tests used, the Rey-Davis pegboard, has been shown to be of mediocre reliability and low discriminatory validity (Graham-White, Merrick, and Harbison, 1969). Confident conclusions are therefore difficult to draw from this study.

Strain, Brunschwig, Duffy, Agle, Rosenbaum and Bidder (1968) compared bilateral ECT (n=42) with unilateral ECT to the right cerebral hemisphere (n=45). These researchers administered a verbal learning test, a visual retention test, and tests of recent and remote long term memory on

three occasions: before ECT, 36 hours post-ECT, and 10 days post-ECT. Although there was no significant difference in degree of impairment in verbal learning 36 hours post-ECT, the bilateral ECT group 10 days later was significantly less impaired than the unilateral ECT group. Both groups improved significantly by 10 days post-ECT on the visual retention test; the degree of improvement, however, was better for the bilateral ECT group than for the unilateral ECT group when compared against their scores 36 hours post-ECT. The two groups' visual retention performance had drawn close together by 36 hours post-ECT, and more indiscriminable by 10 days post-ECT. Remote memory was more effected by bilateral ECT than by unilateral ECT at 36 hours post-ECT; at 10 days post-ECT, the bilateral ECT group was 14% more impaired than the unilateral ECT group. Neither group, at this juncture, had returned to their pre-ECT levels for remote memory. Recent long-term memory performance was very similar to that for more remote memory on all test occasions.

A further followup study (Bidder, Strain, and Brunschwig, 1970) of depressed patients 30 days post-ECT revealed that both bilateral and unilateral ECT groups had surpassed their pre-ECT cognitive level. Another group of patients (n=14) who had received both unilateral and bilateral ECT within a year were also studied; the trend for unilateral ECT to produce less impairment of memory was demonstrated again.

D'Elia (1971) studied two groups of depressed patients, one group (n=25) receiving bilateral ECT, the other group (n=28) receiving unilateral ECT to the right cerebral hemisphere. The bilateral ECT group had significant decrements in verbal recall when tested 3 to 7 days after completion of treatment, whereas the unilateral ECT group did not. This decrement in verbal recall was clearly evident for immediate reproduction and more pronounced for delayed reproduction.

Small, Small, Milstein, and Moore (1972) assigned 14 patients to either unilateral ECT administered to the right or left cerebral hemisphere. All psychotropic medications were withdrawn for the month preceding treatment; this usually exacerbated the patients' acute psychotic symptoms. Memory testing was carried out prior to treatment, after the fifth ECT, and two to three months after treatment. The patients in this series received an average of 14 ECTs. The followup results were interpreted by Small et. al. (1972) as demonstrating "sustained improvement" in memory for both groups. However, this may have been partly attributable to practice effects, as identical test batteries were administered on each of the three occasions. Arguably, as the patients' performance had not deteriorated, a conservative interpretation would state that under these particular conditions no deficit was demonstrated.



Heshe, Röder, and Theilgaard (1978) administered an extensive test battery to 23 depressed patients who received bilateral ECT and 28 depressed patients who received unilateral non-dominant ECT. Only patients with endogenous depressions were included. The tests used included ones measuring verbal learning, verbal memory, picture recognition, visual design learning and memory, face recognition, tactile-spatial memory, attention, concentration, verbal fluency, visual reaction time, fluid movement, and time estimation. In contrast to these sophisticated tests the evaluation criteria for assessing depressive severity were crude, comprising a 3-point scale referenced with clinical descriptions. Therapeutic success was also rated on a simple 3-point scale. All but three of the patients initially examined were rated as mildly depressed ( $n=26$ ) or moderately depressed ( $n=22$ ). There was also a significant difference in the depressive severity of patients in each patient group; the bilateral ECT group contained relatively more moderately depressed patients than the unilateral ECT group. This imbalance occurred despite random allocation to treatment group. No information was provided about the patients' social class, education, intelligence, or use of psychotropic medication during the follow-up period.

Although the total electrical current dosage received by the unilateral ECT group was significantly greater than that received by the bilateral ECT group, their cognitive



side-effects were fewer, briefer, and less pronounced when in evidence. The only statistically significant within-group decrement of the unilateral ECT group at 8 days post-treatment was that they committed more false positives in short-term picture recognition. This completely subsided by the next test session three months later. This group also significantly improved at 8 days post-treatment on visual design memory and recurrent design recognition, and produced more rapid lefthanded finger taps. Their cognitive function further improved at 13 weeks post-ECT: they made fewer errors in verbal memory, and they were more verbally fluent.

The bilateral ECT group had two decrements at 8 days post-treatment; they committed more false positives in short-term picture recognition and failed to recognize more pictures after a one-hour delay. These deficits disappeared by 13 weeks post-ECT. Although the general tendency of the bilateral ECT group was toward improved cognitive function at both follow-ups, their visual design learning declined at 13 weeks post-ECT relative to their own results at 8 days post-ECT, relative to the unilateral ECT group, and to the general norms. Other between-group differences evident at 8 days post-ECT were no longer evident at 13 weeks post-ECT. Both patient groups had lingering small impairments at 13 weeks post-ECT in story recall and simple reaction times relative to approximate normal values. Time Estimation never

approached the objective reference times. These three deficits could have been due to relapses, which occurred in 27% of the patients prior to the final followup.

Jackson (1978) investigated the memory effects of bilateral ECT compared to right or left unilateral ECT. Test administration, one week prior to treatment, 30 minutes after the final treatment, and ten days later, was double blind. Though the second testing would have been confounded by immediate postictal confusion, results at the final testing showed significant improvement for all ECT patients as compared to matched controls. Although assignment to treatment group was randomized, Jackson (1978) provided no information on clinical diagnoses or the depressive severity of each group. However, as Jackson (1978) points out, only 1 of 70 possible differences in memory sub-test score changes reached statistical significance.

Squire and Chace (1975), assessed the memory of 38 patients (all between 42-45 years old) who had received either bilateral ECT, nondominant unilateral ECT, or hospitalization without ECT. These patients had been treated six to nine months previously. The performance of these three groups of patients on six different tests of delayed retention and remote memory provided no evidence of persisting impairment.

Squire, Slater, and Chace (1975) devised and validated an original test that required the correct identification of television series. These programmes had only been broadcasted for a single season between 1964 and 1972. This research was directed at establishing how far back the retrograde amnesia present soon after ECT extended into the past. They found that this retrograde amnesia could extend to between 1.5 and 2.5 years preceding treatment, based on the results of testing depressed patients one hour after their fifth ECT. However, only bilateral ECT produced an effect that could be detected. Further investigation showed that a course of unilateral nondominant ECT produced a nonsignificant improvement for the particular time period (circa 1971-1972) effected by bilateral ECT. However, effects within a year and a half before treatment were not measured by the research instrument.

In footnotes at the end of the article, the research group mentioned that within one to two weeks following complete courses of bilateral ECT (mean ECTs = 7.6, range 5-13) the patients studied had practically recovered to their pre-treatment memory baseline. Squire, Slater, and Chace (1975) reasoned that the memories of the television programmes had not been erased but that access to some memory traces had been temporarily lost. To check this supposition against empirical data, these researchers subsequently administered their television programme test

to 16 patients who had received a course of bilateral ECT (mean treatments = 9.9, range 5-17) approximately six months previously. Their test scores closely matched the scores of 56 normal control subjects. The patients and non-patient controls did not deviate significantly from each other; average percentages of correct responses did not differ between the groups by more than 4% for any of the measured time periods.

This study illustrated the temporal selectivity of the retrograde amnesia associated with ECT, and demonstrated twice that this side-effect is fully reversible. Recovery occurred without any deliberate effort or intervention. It is exceedingly unlikely that any of these patients could have been re-exposed to, or re-learned, the specific, relatively trivial, non-recurring stimuli used in Squire et al's (1975) tests. What is also interesting about this study was that the original memories of the patients would have been initially weaker, by dint of their probable poorer concentration while ill preceding treatment. The presentation of this article was misleading; what was emphasized and remembered most about it, was the temporal extent of the immediate retrograde amnesia. The more important information, concerning its spontaneous reversibility, was relegated to disjointed footnotes without explanation or interpretation.

Johnstone, Deakin, Lawler, Frith, Stevens, McPherson, and Crow (1980) randomly allocated endogenous depressives to a course of eight simulated ECTs or to a course of eight real bifrontal ECTs. A secondary advantage of this was that the psychiatric raters and psychological testers were blind to treatment allocation. Patients were tested before ECT, during or shortly after ECT, and six months later. There were no differences between the real ECT group and the pseudo-ECT group on the percentage of patients complaining about memory or concentration problems on any of these three occasions. Three cognitive tests were also administered either before or during ECT and at the six-month follow-up. The first test was one of word recall; 20 words were read aloud and the patient asked to decide whether each word was "nice" or "nasty". (This step would theoretically lead to an improved depth of processing.) The patients were then asked to count backwards by 7s for 30 seconds, then to recall as many of the words as possible. The second test was a learning task; each patient tried to learn the (visually presented) name, occupation, and town of residence of five photographed individuals. (Frith, personal communication.) The third test was the Famous Personality Test (described in the Methods section). This research group found no persisting impairment on any of these tests. This is a convincing demonstration of this, primarily because of the random allocation of carefully diagnosed patients, 79% of whom had never before received ECT.

Squire, Slater, and Miller (1981), conducted a series of studies to clarify the effects of bilateral ECT on remote memory. Memory was examined on four occasions: before ECT, after the fifth ECT, one week and seven months after completion of the treatment course. Using separate samples of 15 and 10 patients as their own controls, no enduring loss in recall or recognition (respectively) of newsworthy public events was demonstrated. The third sample's (n=18) test approximately replicated the findings of Squire, Slater and Chace (1975). Bilateral ECT produced a temporary retrograde amnesia for television programmes broadcasted one to two years prior to the index course without effecting recall of television programmes before that period.

The fourth study, undertaken in 1975, was a comparison between 10 ECT patients and 7 non-ECT control patients. This was meant to be an assessment of personal memory, both for remote and recent material. Recall of relatively more recent events (the Watergate scandal, Christmas 1973, and particular events on the day of the index hospital admission) was more effected by ECT. The latter item, the day of hospital admission (2-36 days prior to ECT), was the only one which showed no trend toward recovery at followup. This item accounted for most of the enduring ECT-related effect, as evidenced from both within - and between - group comparisons. Some loss may have persisted for details of the Watergate affair, but the ECT patients

experienced no permanent memory loss for events of Christmas 1973.

When remembrances elicited during the first interview were not spontaneously recalled at follow-up, the patients in this part of the study were prompted and asked whether the tester-recounted remembrance seemed familiar or not. At the seven-month followup, the ECT group did not need any more reminders than the non-ECT group, but standardized reminding failed to precipitate the recognition of 69 specific details from the ECT group. The non-ECT group's recognition was flawless. About 55% of the ECT group's cued recognition failures involved events about the day of hospital admission. Such failures were considerably more frequent for recent events than for remote events; marked recovery of the latter occurred between one week and seven months after ECT.

These findings are evidence that memories of the few days before thrice-weekly bilateral ECT can be lost persistently, and that some memories of events that occurred up to two years before such treatment may be vulnerable. Further reservations and limitations could lead one to construe these findings differently. Squire et al (1981) did not blindly match treatment groups or otherwise control for socio-economic class, educational level or intelligence. With the very small sample sizes used in their comparison study, disparities on any of these variables, even between



a few patients, could distort the results. These researchers also under-emphasized the effects of depression on recent personal memory. Therefore it is understandable that they did not measure depressive type or severity. It is less understandable why research diagnostic criteria were not used. However, the testers were not in the dark about treatment disposition, probably not even at the pre-treatment assessment. Although several memory details were elicited with each item, there were only three recent memory items, too few for one to have confidence in the test's reliability. Reliability coefficients were not calculated by Squire et al (1981).

The researchers themselves offer an alternative explanation of their main findings that is related to the unproven reliability of some of their procedures. Interview material was not corroborated; during the first session, the ECT patients may have made more recall errors than the control patients. After ECT, recall of these statements may not have been spontaneous, and because of an undoubted retrograde amnesia of the first interview (which was just before ECT), they could not recognize the reminders. Nevertheless, the compelling implication of Squire et al's (1981) paper is that the strength and duration of subtle retrograde amnesic sequelae related to bilateral ECT are at least suspect.

There are a few contradictions between the various



psychometric researches, as there would be between this number of independent studies on any psychological topic conducted over a long period. For example, Strain et. al. (1968) showed that bilateral ECT had less effect on visual retention than unilateral non-dominant ECT by 10 days post-treatment. However, Halliday et al (1968) showed a lingering relative impairment in visual retention at 90 days post-treatment for bilateral ECT patients as compared to unilateral non-dominant ECT patients. This apparent contradiction may have been due to differences in tests, patient samples, diagnostic criteria, depressive severity, or the different treatment-test intervals.

There have been contradictory findings, but there have also been consistent trends. One main trend has been that memory is more adversely effected by bilateral ECT than by unilateral non-dominant ECT. From the above studies, the average recovery time for patients to attain normal levels of memory function would be estimated to be about 22 days for bilateral ECT and 7 days for unilateral non-dominant ECT. At equivalent times after unilateral non-dominant ECT, the qualitative experience of memory disturbance was also usually reported to have been more circumscribed and less annoying. The other main trend has been toward there being little evidence for a measureable permanent memory deficit that could be attributed correctly to ECT. However, there have been few controlled, methodologically rigorous studies

involving both pre-ECT and post-ECT tests that have extended the follow-up period beyond 90 days. There would be minor limitations imposed on such extended studies, one being the cyclical nature of manic-depressive psychosis. Nevertheless there is an understandable need for this type of study.

E) The effects of ECT on other miscellaneous cognitive functions.

Because the majority of patients' complaints about cognitive function following ECT have pertained to memory, most of the previous research has been guided towards that process. However, it may be possible that some of these patients mistakenly labelled some other cognitive deficit as a memory deficit. It may also be possible that some patients are unaware of a deficit, unless their attention has been specifically directed to it. There have been neuropsychological precedents for this possibility, e.g., an acallosal patient is unaware that each of his cerebral hemispheres is independent of the other; apart from minor dyspraxia, deficits can only be observed under special conditions (Sperry, 1968). Second, as an ECT convulsion spreads throughout the entire brain (Weaver, Williams and Rush, 1976), investigative thoroughness behooves researchers to study a selected range of other cognitive processes. To date, such studies have been sparse, particularly followup studies.

Michael (1954) was interested in those cognitive functions presumed to be predominantly under the control of the frontal cortex. This is reasonable in light of the proximity of the frontal lobes to the usual sites of ECT electrode application, evidence on current density distribution (Weaver et al, 1976), and on related neurophysiological grounds (Roth and Garside, 1962). Using a word fluency test previously validated (Rylander, 1947) on patients who received frontal lobotomies, Michael (1954) tested 30 patients before bilateral ECT and six weeks post-ECT. A significant improvement in fluency was demonstrated. This amounted to an overall 50% gain on the pre-ECT mean score.

Wilcox (1954) administered a comprehensive battery of neuropsychological tests to 23 psychotic patients prior to bilateral ECT, on the day after the tenth treatment, two and twelve weeks later. The tests covered visual perception, concentration, perceptuo-motor factors, vocabulary, and arithmetic. From pre-ECT to one day post-ECT, every test comparison showed a decrement in performance; five such decrements were statistically significant. Two weeks later, nine of the ten measures showed more improvement than Wilcox (1954) could attribute to practice. It is difficult to surmise how he arrived at this attribution: there was no control group tested at similar intervals. At the twelve week post-treatment evaluation, there were further slight improvements.

Although there were design flaws in these two studies, they were not the type of flaws that would lead to significant deficits being missed if they actually existed. However, these studies are fairly dated. One more circumstance exists in which it would be advisable to look again at non-memory cognitive functions, to wit, if persisting memory deficits were demonstrated.

MethodA) Psychometrics - Rationale and Description

To ensure that the test battery assembled for this research covered each significant domain of cognition, the major factor analytic studies in this field were consulted. Each separate analysis varied in some respects from the others, according to the input tests and the particular mathematical technique utilized, but there were broad areas of overlap and agreement.

At the highest general level, Robertson-Tchabo and Arenberg (1976) carried out multiple principal components analyses at three age levels to determine the degree of factor structure invariance with age. Four factors, cumulatively accounting for 69% of the total variance, were identified. The first factor, labelled as an information processing speed factor, reflected the ability to quickly process incoming, paced sequential information, such as in speeded psychomotor tasks. The second factor, described as a secondary memory factor, reflected the ability to retrieve information from memory stores. Delayed free recall and the secondary memory component of immediate free recall loaded on this factor. Attention, the third factor, reflected the subjects' alertness to the demand characteristics of experimental tasks. Tests of sustained concentration, simple reaction times, and delayed verbal recognition loaded on this factor. The fourth factor, termed primary processing efficiency,

reflected the ability to deal with incoming information prior to encoding it for subsequent use, and represented short-term memory (STM). Tasks involving immediate free recall and accuracy in responding to binary sequences loaded on this factor. A minimally thorough cognitive test battery would contain at least one exemplar of each of these factors.

A further consideration is the distinction between verbal-semantic memory and visuo-spatial memory (Sanders, 1968).

A factor analysis of verbal-semantic memory by Brown, Guilford and Hoepfner (1968) demonstrated that six factors were involved in this domain. They were designated and characterized as follows:

- 1) MMU - memory for isolated items of information, as elicited by tests of picture memory, name recall, word recall, and word recognition.
- 2) MMC - memory for classification ideas, as elicited by tests of categorized information.
- 3) MMR - memory for meaningful connections between meaningful items of information.
- 4) MMS - memory for the structure or order of information.
- 5) MMT - memory for changes in information.
- 6) MMI - memory for arbitrary connections between meaningful items of information.

In the allied domain of verbal learning, Games (1962) concluded, "Rote memory would seem to be the major individual difference learning parameter needed in theories of behaviour in verbal learning situations.". He also showed that span memory would not be an effective predictor of performance on most long-term memory (LTM) tasks. This finding corresponds well with clinical observations (e.g., Talland, 1968) and laboratory experiments (Martin, 1978). Further work (Games and Bechtoldt, 1969) replicated the earlier study and also established subsidiary evidence connecting verbal learning with the meaningful memory factor (factor MMR using the Brown et al, 1968, nomenclature).

The authoritative factor analysis of visual memory is by Christal (1958), who administered 29 experimental and reference tests to 718 subjects. Factors were extracted using Thurstone's Centroid Method with orthogonal rotation to simple structure. Three visual memory factors were identified. The first, memory for position in space, is the ability to mentally picture an object in its proper position relative to other objects. The second factor, memory for colour, represented a special ability appropriate to its name; it was relatively independent of general associative learning. The third factor, memory for position in a temporal sequence, was also regarded as a special ability. Although good performance on general associative learning contributed to improved



performance on this factor, its influence alone could not account for the superiority of many subjects on this factor.

Some general conclusions can be drawn from the above studies. First, psychomotor speed is independent from the accuracy and efficiency of other cognitive processes. Second, in the acquisition phase of information processing, facility in associating information is more important than the number of items that can be handled in a single series. Therefore, emphasis can be justifiably placed on the paired-associate task as the appropriate paradigm of how effective linkages are made between old and new stimuli. This is not meant to devalue more elegant forms of concept learning and problem solving, but to recognize the active, fundamental and widespread nature of associative processes. Luria (1973) has commented on their complexity: "... the systems of connections into which traces of information reaching the subject are introduced are coded with respect to different signs, and consequently they form multi-dimensional matrices.". Third, stimuli presented to the eyes will inherently be perceived differently to equivalent stimuli presented to the ears, and once perceived, may be organized differently, and in somewhat different locations within the brain (Luria, 1971).

The remainder of this section details the specific tests used in this research.



## I. Perceptual Aptitude

The adult version of the Cube Analysis Test, validated by Ratcliff (1970), was selected as the marker of visual perceptual ability. Two parallel forms of eleven items each were constructed from the original test. The first variable scored is the discrepancy between the number of blocks in each array and the number of blocks the subject reports in each array. Following Currie, Anderson, and Price (1965) and Korboot and Yates (1973), the second variable derived is inspection time, defined as the time required to inspect each array to determine the number of blocks present. This was ascertained in this research by a 3-second sweep stopwatch accurate to .01 second. Both variables have been shown to significantly discriminate brain-damaged patients from controls matched for age and vocabulary level, particularly when performance was speeded. (Currie et al, 1965). Also, subjects who had received penetrating bullet wounds to the right cerebral hemisphere over twenty years prior to testing had significantly slower inspection times than did similar subjects with comparable injuries to the left cerebral hemisphere (Newcombe, 1969).

## II. Psychomotor Speed

A portable visual choice reaction timer was used to measure two components of psychomotor speed - internal information processing speed, denoted as Decision Time, and peripheral motor speed, denoted as Movement Time. The

apparatus and procedure used are identical to those described by Byrne (1976a).

Byrne (1976a) does not provide any data on reliability, but previous estimates provide a reliability coefficient of .95 from comparable tests on 113 subjects (Lemmon, 1927). The digital electronic timers incorporated in the present device were accurate to .01 second, and were periodically calibrated against a more accurate reference device.

Choice reaction times, the total of Decision Time and Movement Time, have been shown to be slower with increasing age in normal populations (Griew, 1959; Talland and Cairnie, 1961; Rabbitt, 1964; Talland, 1964; Weiss, 1965), more specifically to age-correlated disease (Spieth, 1964), e.g., mild to moderate degrees of cardiovascular disease, with presumed cerebral involvement.

Arrigoni and De Renzi (1964) found that patients with right cerebral hemisphere damage showed significantly slower simple visual reaction times than patients with left cerebral hemisphere damage. Boller, Howes, and Patten (1970) obtained significant correlations between the volume of a brain lesion, as calculated from brain scan images, and simple auditory or visual reaction times. This relationship held for right cerebral hemisphere lesions but not left cerebral hemisphere lesions.

Hagberg and Ingnar (1976) found, in a sample with clinically diagnosed presenile dementia, that greater degrees of cerebral impairment were associated with slower choice reaction times. Cerebral impairment was measured by 8 - or 32 - channel regional cerebral blood flow detector equipment. There was a proportional relationship between the degree of cognitive deficit and a decrease of the cerebral blood flow, especially the flow in the grey matter. A sub-group of these patients, who had impairment limited to the temporal lobes and/or adjacent areas, were not significantly different from normal controls on a disjunctive reaction time task. However, the joint weight of these papers and others (Benton and Joynt, 1959; Blackburn and Benton, 1955; Costa, 1962; Schafer, 1944; Halstead, 1947; King, 1975; Doshier, 1979) provide strong evidence for the validity of a choice reaction time test as a sensitive index of cerebral impairment. Indeed, King (1975) summarized his review of this subject thus: "... brain damage contributes far more than depressive mood to slow response speeds.". A technique that measures such speeds seems apposite in the context of ECT sequelae research.

### III. Learning

There were three learning tests incorporated in this test battery. They cover associative learning tasks in three areas: auditory-verbal learning, visual design learning, and positional learning. There are four reasons for this

emphasis on associative learning. First, organizing stimuli by association is particularly important in memory tasks that require the storage or learning of large amounts of information (Deese, 1965; Mandler, 1967; Atkinson and Shiffrin, 1968; Baddeley and Patterson, 1971). Second, the approximate interelectrode path of the electric current in bilateral ECT passes near to the hippocampus. This structure, located on the floor of the lateral ventricles, has been implicated in associative processes (Blakemore, Iversen, and Zangwill, 1972) on the basis of detailed electrophysiological and neuropsychological evidence. Third, each modality of stimuli presentation requires a separate analysis, as there are more than superficial differences between the auditory and visual modalities (Guilford, 1947; McGhie, Chapman and Lawson, 1965; Margrain, 1967; Sanders, 1968; Schulman, 1973). Fourth, paired associate learning has been evaluated as a highly sensitive test (McNair, 1973).

The reliability of auditory-verbal paired-associates tests has been estimated to be between .85 and .90 (Lemmon, 1927; Garrett, 1928). Their discriminatory validity has also been established on many occasions (e.g., Walton, Graham-White, Black, and Young, 1959; Graham-White, Merrick, and Harbison, 1969; Irving, Robinson, and McAdam, 1970). Visual paired-associates tests have been assessed as having reliability co-

efficients between .78 and .98 (Garrett, 1928; Kelley, 1928). Their discriminatory validity has been supported in a study of the cognitive sequelae of temporal lobectomies (Meyer, 1957).

The positional learning test was developed by the author because there were no suitable tests available. A test was needed to assess the new learning of multiple locations of three-dimensional objects in relation to fixed two-dimensional reference positions. The subject was shown an array of four picture-block combinations to study for 30 seconds. Four combinations were chosen on the basis of pilot study experimentation, and from what is known about the average normal memory span for spatial positions (Sanders, 1968). The pictures were selected from the Symonds Picture Story test (Symonds, 1948), and the blocks were derived from Vygotsky (1962). After the 30 second learning period, the array was hidden from the subject's view for 10 seconds, and then the pictures alone were re-displayed in random order. The subject was then asked to place the correct block in its correct location (e.g., corner, top or side) upon the correct picture. Any errors were corrected, the array re-displayed, and the procedure repeated until the subject attained the criterion of three consecutive correct locations for each picture-block pair. As soon as the criterion was reached for an individual picture-block combination, it was dropped from further arrays. The

score was the number of presentations and corrections to attain the criterion. A block paired with the wrong picture scored one correction; a block paired with the correct picture but in the wrong location scored a half correction. Tests of this approximate type have attained split-half reliability coefficients ranging from .80 to .92 (Christal, 1958).

#### IV. Memory

There were seven memory tests presented to each patient on every testing occasion, and an additional one presented at the seven month followup.

The first of these tests is Delayed Recall (Williams, 1968). The three parallel forms of this test have been shown to be equivalent, correlations between each pair of versions ranging between  $+ .59$  and  $+ .66$ , statistically significant at  $p < .0005$ . The test-retest reliability between parallel forms is  $.57$ ,  $p < .001$ . As there is a significant relationship ( $p < .025$ ) between low delayed recall scores and the presence of electroencephalographic abnormalities (Graham-White, Merrick, and Harbison, 1969), and significant positive relationships with valid tests (Gentz, 1976), it can be said to be valid. Subjects were asked to study an array of nine everyday objects for 30 seconds, naming each object to ensure minimum attention. The Personal Remote Memory Test was then administered, to interfere with sustained rehearsal. Subjects were then

asked to recall as many objects as they could, then asked if they recognized any other previously viewed objects in a larger array. Two scores were derived, one for delayed recall and one for delayed recognition.

The Sentence Repetition Test was developed from sentences devised by Newcombe and Marshall (1967). These researchers systematically varied the normal syntactic and semantic constraints of sentences. Sentences which discriminated subjects with left cerebral hemisphere lesions from those with right cerebral hemisphere lesions, and from normal controls, were those which violated semantic rules or whose structure provided scope for semantic confusions. The subjects with left cerebral hemisphere lesions were not impaired in their knowledge of linguistic regularities, but were handicapped in realizing the details of this knowledge, and in recalling the sentences. (Zangwill, 1943, 1946; McFie and Piercy, 1952). In addition to the six original sentences, which were made somewhat longer, three additional parallel versions of six sentences each were constructed using the Newcombe and Marshall procedure, i.e., systematic sentence degradation. Subjects were asked to repeat each sentence immediately after the tester read it, after first trying two practice sentences. The score was the total number of words in error by mislocation, incorrectness, or omission. Half credit was given for words in error correctly repeated on a second attempt.



The Logical Memory sub-Test (Wechsler, 1945) measures immediate recall of a brief paragraph. Its reliability coefficient has been estimated to be .78 to .83 (Simpson, 1912), .60 (Lemmon, 1927), .814 (Hall and Toal, 1957), and .83 (Russell, 1975). Four factor analytic studies of combined groups of neurological and psychiatric patients have consistently found the Logical Memory Test clustered along a Memory factor, irrespective of the specific factor analytic technique employed (Bachrach and Mintz, 1974; Davis and Swenson, 1970; Dujovne and Levy, 1971; Kear-Colwell, 1973). This, in addition to other clinical evaluations (Nelson, 1953; Talland, 1962; Whitehead, 1973; Gentz, 1976) lends weight to its validity. Subjects were asked to recall as much of a paragraph as possible immediately after the tester read it. The score was the number of word-concept groups correctly recalled, irregardless of serial order or whether alternative words of similar meaning were substituted for the original words.

The Verbal Memory Test, designed by the author, incorporated procedures based on signal detection theory to provide separate indices for each subject's response bias and memory sensitivity, as recommended by Clark, Brown, and Rutschmann (1967). Response bias has been shown to be intimately related to the process by which decisions are made about stimulus recognition. In a dichotomous recognition task, Egan (1958) found that as a subject



relaxed his response bias from a previously stricter one, additional stimulus information was utilized. The numerical value of response bias was found to be dependent upon the following variables:

- 1.) The degree of recognizability of the stimuli.
- 2.) The a priori probabilities of the stimuli being targets or distractors.
- 3.) The costs and values of true and false positives and negatives.

The available evidence suggests that a subject sets his response bias so that he will probably choose a number of items approximating to the number of items seen at the initial inspection (Parks, 1966). The association between subjective confidence and actual recognition success has been found to be high (Brown, 1965). However, as McNicol (1972) has said, "The concept of internal noise carries with it the implication that all our choices are based on evidence which is to some extent unreliable (or noisy)... An experimenter must expect his subjects to 'remember' stimuli which did not occur. So, false alarms are endemic to a noisy memory system.". There are compatible neurological models (e.g., Pinneo, 1966) to justify the use of a signal detection theory approach. These models use the concept of neurological noise, by which is meant ambient neural activity. A particular increase in neural activity above the background level of random discharge

is identified as signal. Signal detection is a function of the signal-to-noise ratio. While a weak signal in a "quiet" background will be detected, the same signal in a "loud" background may not be. Gregory (1959) theorized that as a person ages, spontaneous neuronal discharge tends to increase, resulting in an increase of neural noise. Spontaneous neural noise could also be present in depression, or to increase with increasing depressive severity. The associated recurring morbid thoughts of depression could also be conceptualized as psychological noise. Byrne (1976b) related the poor signal detection of psychotic depressives to hypo-arousal relative to normals, and related the high false-positive rates of neurotic depressives to hyper-arousal. It could also be hypothesized that ECT temporarily produces more pronounced neural noise while counteracting the aforementioned morbid ideation.

The validity and utility of a signal detection analysis of memory has been shown in studies of closed head injuries (Brooks, 1974), and of elderly depressives, demented, and normal controls (Miller and Lewis, 1977).

The Verbal Memory Test utilizes the six response words previously learned to criterion in the Verbal Learning Test. Printed on large cards, the six "signal" words were randomly mixed with six semantically similar "noise" words and six structurally similar "noise" words (see

Appendix for Verbal Memory Test word lists). The subject was requested to place the words he could remember hearing earlier in the session beneath an envelope marked "Remembered", and those he could not remember beneath an envelope marked "Not Remembered". This dichotomous forced-choice procedure was recommended by Clark et al (1967). There was no forewarning, and the delay between the learning test and the memory test was 45 to 48 minutes. True and false positives were noted, then later converted to hit rates and false positive rates. Whenever the false positive rate was zero, the approximation suggested by Armitage (1971) was employed; this uses the formula  $p = 1/(2n)$ , where  $n$  is equal to the number of choices. Appropriate tables (Freeman, 1964) were then consulted to obtain scores for sensitivity and response bias.

The Incidental Visual Memory Test was designed by the author to assess the amount of unlearned information, displayed visually, that would be retained after a delay of 42 to 45 minutes. Specific questions were asked about the array in the Positional Learning Test, without forewarning. Questions pertained to the number, colour and shape of the wooden blocks (1, 2, and 4 points respectively), to the nonsense trigrams inscribed on the blocks (2 points), and to the colours and specific attributes of the pictures (1 and 8 points respectively). Eighteen (18) points was the maximum score.

Kausler and Lair (1965) presented data on incidental verbal memory to demonstrate that, with increasing age, a greater proportion of rehearsal time is devoted to the exact (non-incidental) task requirement, thereby limiting the amount of attention to less relevant (incidental) components of the task. Older subjects (mean age 55, range 50 - 65) were deficient in remembering incidental components of learning tasks, even when intentional performance was not markedly effected. McGhie et al (1965) found that visual retention declined with age. Depression and ECT could increase the level of ongoing interference during stimulus perception, and between perception and retrieval, thus effecting visual retention in a similar manner to normal ageing.

The Personal Remote Memory Test was derived from one used previously to study the cognitive sequelae of ECT (Bidder, Strain, and Brunschwig, 1970). This test's authors presented no data on reliability; however Woodrow (1927) found, with a similar test measuring memory for dates and events, a reliability coefficient of .65 - .75.

The score of the Personal Remote Memory Test was the total number of memories recollected. As the same form of this individualized test was presented at each testing occasion, it was also possible to ascertain the number of positive and negative discrepancies between adjacent

testing occasions. A positive discrepancy was defined as a previously non-recollected item that was recollected on retest. A negative discrepancy was defined as a previously remembered item that was forgotten at retest. A supplementary form was presented at the final session.

The Famous Personality Test (Stevens, 1979) was used to measure impersonal remote memory. It was based on the self-reported degree of familiarity of the names of personalities who had been famous for varying periods during the past fifty years. A personality's name was selected for the test if his face and name had been famous. Ideally, each personality would have been in the public eye for only a short period of time, e.g., he would figure in a scandal which was heavily publicized for a short time.

Items were included in the test on the basis of a large-scale study. This validation study involved the use of two parallel questionnaires, each containing names of celebrities who were at the peak of their fame during specific 5 year periods between 1930 and 1975. Each of these questionnaires contained 329 names. The personalities were judged to be famous at these particular time periods on the basis of information retrieved from newspapers: the Daily Mirror (1930-1975), The Times (1930-1975), and the London Illustrated News (1930-1945).



Modern history books and specialist books on the history of sport and popular music were also consulted. Additional help was also provided by Gallup Polls, Madame Tussaud's Museum, the Social Science Survey Archives at Sussex University, and Mr Leslie Welch, the "memory man" of a 1950s television programme. The names of famous personalities were derived from five source groupings: contemporary figures, British politicians, foreign politicians, musical stars, and sports-persons. Names were then selected which accurately discriminated between subjects of different age groups. This procedure obviated the difficulty of attempting to decide which names were specific to certain time periods.

This author conducted three further local pilot studies on the Famous Personality Test, to eliminate names which were not usable verbally and to equate five parallel versions.

Each parallel form comprised 60 names, ten names from each decade from 1930, and ten fictitious names. The inclusion of fictitious names allowed an estimate of false positive responses. The proportions of male and female names on each parallel test were identical. The subject's task was to indicate his confidence as to whether he recognised each name. No points were awarded if he did not recognize a name at all; two points were awarded if he definitely recognised a name; and one point if he vaguely recognized a name or was uncertain.

The Face-Name Test, based on experimental models (e.g., Borges and Vaughn, 1977), was designed to test the frequent complaint of an inability to recall the name of an acquaintance. A milder variant of this problem consists of long (sometimes embarrassing) delays in remembering a name. This inability is accompanied by a feeling of familiarity concerning the physiognomy of the person perceived, thereby excluding facial agnosia.

Each subject was shown twelve realistic 6 inch by 4 inch colour photographs of individuals, six males and six females. Each photograph was shown for three seconds; there was a three second interval between each display. On each of three displays of each face, which were in random order, the name of the person represented was read aloud by the tester. All names used were commonplace, e.g., Rob Laing. The subject was warned, both before and after the photographs were shown, that he would subsequently be required to match the correct names to the faces. For the following ten minutes, the subject was occupied with other mental tasks, such as the Personal Remote Memory Test (Supplement). He was then given 36 name labels, 12 of which contained the correct names, and he was asked to match the correct name to each face. The score was the number correctly matched. This test has been shown to significantly discriminate chronic cigarette smokers from matched non-smokers (Weeks, 1979).

## V. Miscellaneous Cognitive Tests

Two tests which measure one common factor, that of predictive planning, are the Mental Set Shifting Test (Bendefeldt, Miller, and Ludwig, 1976) and the Porteus Mazes (Porteus, 1965). The former is in the auditory modality and the latter in the visual modality. Set is the bias to attend to some aspects of the available sensory information and ignore other aspects. Set shift is the inhibition of one set in order to assume another set, to stop perseverating in a once-appropriate way, and replace it with more appropriate perseverations. Malmo (1948) and Robinson (1949) have administered "set shift" tests to psychiatric patients before and after psychosurgery; these researchers found set shifting to be more difficult for patients with damaged frontal lobes. Frontal lobectomy cases maintain a set rigidly, or are unable to shift set, despite a mounting number of errors (Halstead, 1947), whereas when normal subjects commit errors, realization forces set change. Mettler (1952) found that the inability to shift set gave the clearest indication of intellectual change after leucotomy.

The Mental Set Shifting Test required the subject to continue sequencing letter-number pairs after the experimenter first read "A-1, B-2, C-3 ....", continuing until Z-26. The next task required the subject to shift set to continue the sequence "A-2, B-4, C-6 ....", continuing until Z-52. The final task began with the more difficult



segment "B-3, D-6, F-9 ....". Each task was timed. Three scores were obtained: the average time, average number of errors, and the number of correct set shifts. This test was administered at the four-month followup.

The Porteus Mazes were selected because of their sensitivity to the effects of frontal lobotomy, both in the short-term (Porteus and Kepner, 1944) and at long-term follow-up (Smith, 1960; Porteus and Diamond, 1962).

Maze tests are also sensitive to the sequelae of temporal lobectomy (Brown, French, Ogle, and Johnson, 1956).

McNair (1973) rated maze tests as being of average sensitivity to minor tranquillisers. Administration as recommended by Foulds (1951) was used. Two scores were obtained: the mean time to traverse each maze from the year VII through the Adult level, and the number of entrances into blind alleys. Patients with cerebral impairment perform markedly worse on this latter variable (Shapiro, Kessell, and Maxwell, 1960). This test was administered at the seven-month followup.

The Verbal Fluency test was used to assess linguistic facility. This test has been shown to be sensitive to left frontal lobe dysfunction (Borkowski, Benton, and Spreen, 1967). Verbal fluency generally declines in patients with cerebral lesions, more so in left cerebral hemisphere lesions than right cerebral hemisphere lesions. (Perret, 1974). Benton (1968) found no significant

difference on verbal fluency between patients with bilateral frontal lesions and left frontal lesions. Using only a verbal fluency measure, Caltagirone, Gainotti, Masullo, and Miceli (1979) obtained an 80% correct identification rate and 14% false positive rate in discriminating early dementia cases from patients suffering from neuromuscular or peripheral nerve diseases. Schaie and Strother (1968) estimated that the test-retest reliability coefficient of this test after seven years was .86. The patient's task was to name as many words beginning with the letters A, M, and S as they could within two minutes per letter. Verbal fluency remains sensitive to brain dysfunction across variations in time limits of between 1 - 5 minutes (Cauthen, 1978). Proper nouns were disallowed. This test was administered at the seven-month followup.

The measure of verbal intelligence used in this study was the Mill Hill Vocabulary Test, Forms A and B (Raven, 1962). Clinical studies (Wells and Kelley, 1920; Simmons, 1933, 1934; Shipley and Burlingame, 1941) have shown that vocabulary level was a good measure of original capacity, and is little influenced by psychoses, whereas measures of abstract reasoning were moderately to severely distorted in the psychoses. The reliability coefficient of Form B alone has been reported to be between .90 and .98 (Foulds and Raven, 1948). Vocabulary tests have also been shown to be little effected by ECT, either soon

after treatment (Smykal and Wilson, 1950), or at eleven days or six months after treatment (Huston and Strother, 1947).

The measure of non-verbal intelligence used in this study was the Advanced Progressive Matrices (Raven, 1958). Administered without time limits it is a measure of intellectual capacity, requiring chiefly the deduction of relations among abstract designs. This test has proved useful where estimates of general intellectual level are required in situations where it is difficult to administer the instructions for more complicated tests. In this study, it was used only as an adjunctive aid, to check against the intelligence estimate obtained from the Mill Hill Vocabulary Test, and information concerning previous educational/occupational attainment.

A self-report measure, the Cognitive Failures Questionnaire (CFQ), was also used. This measure has been shown to be uncorrelated with neuroticism, psychoticism, extraversion, social desirability or Lie scales (Broadbent, 1979). The CFQ consists of 25 items concerning the frequency of various common errors of perception, memory, and action. Data on validity were provided by 24 married couples. Each individual completed the CFQ and 8 rating scales concerning the observed forgetfulness, specific instances of lack of concentration, etc. of their spouse. Every correlation between every observer rating scale and

every CFQ scale was positive; 70% were statistically significant. Data on reliability were derived from 37 student nurses who were tested at 6 - week intervals on 5 successive occasions. The initial CFQ had a Kendall's rank correlation coefficient of .506 with the final CFQ. Further samples of 101 student nurses and 57 male business executives, both of which were followed for over a year, again demonstrated test-retest rank correlations in excess of .50. A similar inventory devised independently (Herrmann and Neisser, 1978) has also been shown to be reliable, receiving a test-retest correlation coefficient of .68 after five months ( $n=41$ ).

There were several reasons why the CFQ was used. First, the distinction between self-reports of cognitive functioning and clinical psychometry was based on more than superficial differences. Everyday cognitive failures are, by definition, more ecologically valid than those produced under rigorous testing conditions. The subject's motivation, for example, may be different in different contexts. Most contemporary memory theories are based on the results of specialized laboratory experiments. However, so little is known about the use of memory in everyday life that it is not known whether or not these theories apply outside the laboratory. Second, previous research (Squire and Chace, 1975) has shown disparities between objective tests and self-report information. These discrepancies occurred more often amongst patients

who had received bilateral ECT than amongst those who had received unilateral non-dominant ECT or inpatient care without ECT. Third, it is possible that a small degree of memory impairment could go undetected even when sensitive objective tests were used. Fourth, if some questionnaire items differed from the objective test results, these items could act as a guide for further research.

#### VI. Lateral Dominance Assessment Scale

Lateral dominance is the preferred use and superior ability of one side of the body as compared to the other side. Information about laterality was used as an acceptable non-invasive way to infer cerebral dominance in depressed patients. The best-discriminating items to assess laterality were selected from previous large-scale investigations (Harris, 1958; Oldfield, 1971).

Attention was focussed on those items which consistently achieved high loadings on a manual preference factor, and high ratings of strength of hand preference on that factor (White and Ashton, 1967). Manual preference has been shown to be strictly uni-dimensional. (Richardson, 1978).

Comparable laterality assessment procedures possess very good reliability coefficients ranging between .78 and .88 for hand dominance, and .71 for eye dominance. McMeekan and Lishman (1975) reported a test-retest reliability of .97 on 73 subjects retested after 14 weeks with the

Edinburgh Handedness Inventory. Sherman, Kulhany and Burns (1976) reported a reliability coefficient of .97 for a handedness questionnaire. The correlation between this questionnaire and a handedness performance measure was  $+.96$ , thus providing validity evidence.

In the present study, laterality was assessed on a 12-point scale composed of observed hand performance items, i.e., handwriting, use of scissors, taking a lid off a box, and the speeded dealing of cards from each hand; reported hand preference items, i.e., using a toothbrush, using a knife, throwing a ball and using a hammer; and observed eye dominance items, i.e., monocular tests, e.g., looking into a kaleidoscope, and binocular tests, e.g., Harris' (1958) bombsight device. Subjects scoring between 9 and 12 were classified as dextrals; between 0 and 3 as sinistrals, and between 4 and 8 as ambidextrous.

Because side effects are likely to be worse if unilateral ECT is given to the dominant hemisphere, laterality should be established. Only one fourth of all persons are completely right-handed, and slightly more than one third show marked dominance of the left hemisphere, whereas the rest are distinguished by relatively slight dominance of the left hemisphere. In one tenth of all cases, left hemisphere dominance is absent (Zangwill, 1960; Palmer, 1964; Subirana, 1969). The ambidextrous and left-handed

populations are heterogeneous for lateral specialisation (Benton, 1962): some 60% have predominant language functions in the left hemisphere and about 40% have the opposite organisation. Left-handed subjects may have a tendency toward hemispheric equipotentiality for recognition of both verbal and non-verbal material (Hatta, 1976). Lack of clear cerebral dominance is also somewhat commoner in females.

### VII. Psychopathology Scales

The Hamilton Depression Rating Scale (Hamilton, 1960) was the primary measure of psychopathology used in this study. It was based on factor analytic data derived from 272 depressed in-patients. The scale's main purpose was to provide a simple way of assessing the severity of a patient's depression quantitatively, and for showing changes in the condition. Its inter-rater reliability coefficient is .90 (Hamilton, 1960). Hamilton (1967) states that ".... in practice, the difference (in total scores, between two trained interviewer-observers) is rarely more than two points."

The Wakefield Self-Rating Scale (Snaithe, Ahmed, Mehta, and Hamilton, 1971) was used as a secondary measure of depressive severity. Its maximum validity coefficient, estimated by correlating it with the Hamilton Rating Scale, was .87. Its minimum test-retest reliability was estimated to be .68.

The Middlesex Hospital Questionnaire (Crown and Crisp; 1966) was administered to each patient at the pre-treatment interview session. This brief screening inventory was intended to cover the range of common neurotic symptoms. The MHQ provides measures on six scales, each scale containing scored (0-2) answers in response to questions, thus giving scores ranging from zero to sixteen on each scale. The scales are anxiety, phobic fear, obsessionality, somatization, depression, and hysterical personality. Initial studies have established its general validity in relation to expert clinical categorization of psychiatric out-patients and normal subjects.

The Newcastle diagnostic index (Carney, Roth, and Garside, 1965) was also used in this study. It was based on multiple regression analyses of the signs and symptoms of 116 depressed in-patients. From these analyses the 18 best predictive features were chosen and weighted coefficients derived for the differential diagnosis between neurotic and endogenous depression. To use this index the presence of any relevant feature is scored as indicated by the weighted value. A depressed patient with a diagnosis score of 6 or more is likely to be an endogenous case and with a score of 5 or less, neurotic.

The same features, with different weights, can also be used to predict response to ECT at 3 and 6 months post-



treatment. A total score of 1 or more is associated with good outcome, whereas a score of 0 or less is associated with poor outcome.

TABLE A

Summary of published test reliability estimates.

<u>Test</u>	<u>Reliability Estimate</u>	<u>Method</u>	<u>Reference</u>
Choice Reaction	.95	test-retest	Lemmon, 1927
Verbal Learning	.85 - .90	test-retest	Lemmon, 1927 Garrett, 1928
Visual Design Learning	.78 - .95	test-retest	Garrett, 1928 Kelley, 1928
Positional Learning	.80 - .92	split-half	Christal, 1958
Delayed Recall	.57	test-retest	Graham-White, et al, 1969
Logical Memory	.78 - .83 .60 .814 .83	internal consistency	Simpson, 1912 Lemmon, 1927 Hall and Toal, 1957 Russell, 1975
Personal Remote Memory	.65 - .75	test-retest	Woodrow, 1927
Face-name Test	.77 .88	test-retest alternate form	Weeks, 1979
Verbal Fluency	.86	test-retest	Schaie and Strother, 1968
Mill Hill Vocabulary	.90 - .98	test-retest	Foulds and Raven, 1948
Progressive Mat- rices	.83 - .93	test-retest	Foulds and Raven, 1948
Cognitive Failures Questionnaire	.506 (tau)	test-retest	Broadbent, 1979

(Continued)

Table A. (Continued)

<u>Test</u>	<u>Reliability Estimate</u>	<u>Method</u>	<u>Reference</u>
Hamilton Depression Rating Scale	.90 (n=70) .91 (n=48)	inter-rater agreement	Hamilton, 1960 Endicott et al, 1981
Wakefield Self Rating Scale	.68 (n=25)	test-retest	Snaith et al, 1971
Middlesex Hos- pital Questionnaire			
free-floating anxiety	.50, .64, .77, .82	test-retest	Crown and Crisp, 1966;
phobic fear	.37, .68, .73, .76	split-half	Crown, Duncan, and Howell, 1970;
obsessionality	.43, .44, .73, .76		
somatic symp- toms	.37, .41, .55, .68		
depression	.35, .58, .65, .72		Rooney, Beaumont, Murphy, and Donald, 1971
hysterical personality	.55, .63, .72, .84		

MethodB) Subjects

All patients admitted to the Royal Edinburgh Hospital between October 1977 and February 1979 with an admission diagnosis of possible depressive illness (n=469) were screened (by the author and a research psychiatrist) to see if they could fulfil the inclusion criteria of this study. These criteria were as follows: age between 18 and 70; a clinical diagnosis of depressive illness; no evidence on clinical examination of organic brain disease, epilepsy, previous neurosurgery, alcoholism, or schizophrenia. In doubtful cases the Present State Examination (Wing, Cooper, and Sartorius, 1974) was used to diagnose depression and exclude schizophrenia or other

non-depressive psychoses. Patients with a history of head injury requiring admission to hospital (in Edinburgh all patients presenting at hospital with a recent history of loss of consciousness, however short, are admitted overnight) were excluded from the study, as were patients who had received ECT in the previous six months, or who were taking regular major tranquillizers.

Of those patients who were screened, Table 1. shows the numbers of patients not included in the study due to the above grounds. In addition to these, 44 other patients were not included in the study because they were too severely depressed, because they wished not to participate in the study, because their psychiatrist did not authorize their participation, or because their grasp of English was inadequate.

Table 1. Numbers of screened subjects not included in the study.

<u>Grounds for Non-Inclusion</u>	<u>Numbers</u>	<u>Grounds for Non-Inclusion</u>	<u>Numbers</u>
Under age 18	0	ECT in prior 6 months	21
Over age 70	38	Regular major tranquilisers	2
Not clinically depressed	140	Alcoholism/ schizophrenia	1
Organic brain disease	41	Alcoholism and ECT in prior 6 months	1
Epilepsy	2	-----	
Neurosurgery	3	Too severely depressed/ mute/stuporous	17

<u>Grounds for Non-Inclusion</u>	<u>Numbers</u>	<u>Grounds for Non-Inclusion</u>	<u>Numbers</u>
Alcoholism	42	Refusal to participate	20
Schizophrenia	26	Psychiatrist did not want patient tested	6
Head Injury	0	Not an English speaker	2

Accepted patients were dropped from the study because of the development of a major physical illness (e.g., myocardial infarction or carcinoma) during the study; the prescription of regular major tranquillizers in therapeutic dosages; any self-poisoning that resulted in loss of consciousness; or receiving a second course of ECT during the six month followup period. (Most patients received a single course of ECT, but a few received further treatments. If these were separated by less than two weeks from the original course, then the course was regarded as continuous.)

Of the patients who fulfilled all the trial criteria, 51 subsequently went on to receive a course of ECT, 17 of these receiving unilateral ECT to the non-dominant hemisphere and 34 bilateral ECT. From those remaining depressed patients (n=56) who did not receive ECT and who fulfilled all the trial criteria, 51 patients were blindly group-matched (by an independent clinical psychologist) to the ECT group on age, sex, social class

(by Registrar General occupational category), educational attainment, and severity of depression (See Tables 2 and 3).

Table 2.

Matched variables of patient groups and normal control group.

Variable	ECT group (n=51)		Non-ECT group (n=51)		Non-patient controls (n=51)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	52.4	12.5	49.0	14.8	51.0	14.2
Education (years)	10.8	3.0	10.6	2.5	10.5	2.0
Initial level of depression (by Hamilton rating) (by Wakefield rating)	26.6	7.5	26.4	7.7	not applicable	
	25.0	7.0	24.5	5.6	10.6	6.5
Sex distribution						
Females N =	34		30		34	
Males N =	17		21		17	

The difference in the sex distribution between the patient groups is not statistically significant (Chi-square = 0.377, small N correction applied, degrees of freedom = 1).

Table 3. Matched variables of patient groups and normal control group (continued).

Social Class Distribution.

Group	Social Class				
	I	II	III	IV	V
ECT	6	10	16	12	7
Non-ECT	7	5	19	10	10
Normal Controls	9	2	26	9	5
Total	22	17	61	31	22

The differences in the social class distributions between the groups are not statistically significant (Chi-square between patient groups = 2.782, not significant, degrees of freedom = 4).

Table 4. Mean ages (years) of patient groups and non-patient control group cross-tabulated by sex group membership.

Group	Males	Females	Both sexes
ECT	50.9 (14.1)	53.5 (11.6)	52.4 (12.5)
Non-ECT	49.2 (13.2)	48.9 (16.1)	49.0 (14.8)
Non-patient	49.8 (15)	51.7 (14)	51.0 (14.2)

(Standard deviations in parentheses)

There are no statistically significant differences between



the groups on age.

Table 5. Mean education level (years) of patient groups and non-patient control group cross-tabulated by sex group membership.

Group	Males	Females	Both sexes
ECT	10.8 (3.1)	10.8 (2.9)	10.8 (3.0)
Non-ECT	10.8 (3.1)	10.5 (1.9)	10.6 (2.5)
Non-patient	11.1 (2.5)	10.2 (1.7)	10.5 (2.0)

(Standard deviations in parentheses)

There are no statistically significant differences between any of the groups on educational attainment.

Table 6. Mean social class of patient groups and non-patient control group cross-tabulated by sex group membership.

Group		Social Class		
		Mean	SD	SE of the mean
ECT	Males	3.47	1.12	0.27
	Females	2.85	1.21	0.21
Non-ECT	Males	3.19	1.44	0.31
	Females	3.23	1.17	0.21
Non-patient	Males	2.94	1.39	0.34
	Females	3.00	1.04	0.18

Of the 51 subjects in the ECT group, all 51 were tested one week post-ECT, 45 at four months and 41 at seven months. Of the 51 subjects in the non-ECT group, 47 were tested at four months and 46 at seven months. Four subjects, two in each group, committed suicide. Other subjects were excluded because of substantial drug overdoses (2), development of physical illness (3), and continued non-attendance (6). In most cases in this latter category, the patients wished to relegate to the past anything which reminded them of their depression. There were no statistically significant differences between the groups with respect to these variables. The initial close resemblances on the matched variables were not significantly effected by these exclusions. (See Table 7.)

Table 7. Matched variables of patient groups at follow-up, allowing for exclusions.

Variable	ECT group				Non-ECT group			
	4 months		7 months		4 months		7 months	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	52.4	13	51.8	13.1	48.8	15	49.1	15
Education (years)	10.9	3.1	10.9	3.1	10.7	2.5	10.7	2.5
Social class (numbers)								
I	5		5		7		7	
II	9		9		5		5	
III	14		12		16		15	
IV	11		11		9		9	
V	6		4		10		8	
Level of depression								
Hamilton	12.6	10.6	10.7	9.7	10	7.2	11.3	8.7
Wakefield	14.4	10.5	12.8	9.7	14.9	9.2	15	8.9
Sex distribution (numbers)								
Females	28		26		29		28	
Males	17		15		18		18	



From a larger group (n=130) of community volunteers, 51 subjects were group-matched to the ECT group on age, sex, social class, educational attainment, and verbal intelligence. (See Tables 2, 3, 4, 5, 6). None of these subjects suffered from any readily apparent formal psychiatric illness or were receiving psychotropic medication. The purpose of this normal control group was to ascertain baseline levels on each of the psychometric tests when given by the same tester in the usual manner. There were no significant differences between the three groups on the matched variables. Both patient groups and the non-patient group were also very similar on a range of other variables that were not intentionally matched (See Table 8).

Table 8. Other resemblances between patient groups and normal controls.

Variable	ECT group		Non-ECT group		Non-patient controls	
	Mean	SD	Mean	SD	Mean	SD
Verbal intelligence	99.5	12.8	98.2	9.4	101.9	10.6
Non-verbal intelligence	95.9	14.0	94.4	13.5	96.9	13.3
Number of prior episodes of depression	2.6	2.9	2.04	2.4	0.27	0.56
mania	0.04	0.28	0.12	0.38	0.00	0.00
physical illness	0.73	0.85	0.82	1.09	0.85	0.89
Cerebral dominance in 51 cases						
Left	44		44		49	
Right	3		4		1	
Mixed	4		3		1	

Middlesex Hospital/

	ECT group		Non-ECT group		Non-Patient controls	
	Mean	SD	Mean	SD	Mean	SD
Middlesex Hospital Questionnaire						
total symptom score	49	12.4	49	10.8	25.8	5.4
free floating anxiety	11.2	3.2	11.3	2.8	5.8	3.5
phobic fear	7.4	4.2	7.3	3.7	3.8	2.7
obsessionality	9.5	3.7	9.9	2.9	6.7	3.4
somatisation	9.7	3.6	10	3	5.2	2.8
depression	11.2	3.2	10.8	3	4.3	3.3
hysterical personality	3.8	3.2	4.4	2.9	4.6	3.2
Broadbent Cognitive Failures Questionnaire						
	71.8	19.7	69.2	15	69	13.8

Clearly, the non-patient control group differed from the patient groups in amount of past and current psychopathology. There were no statistically significant differences between any of the groups with respect to cigarette smoking. (See Table 9.)

Table 9. Smoker and non-smoker distributions within the patient and non-patient groups.

Group	Non-smokers	Moderate smokers	Heavy smokers
ECT	22	5	24
Non-ECT	23	3	25
Non-patient	29	4	18

There were also no statistically significant differences between the patient groups with respect to alcohol use. The non-patient group admitted to less "regular" drinking and more "occasional" drinking. However, these differences did not attain statistical significance. (See Table 10.)

Table 10. Alcohol consumption, patient and non-patient groups.

Group	Teetotal (n)	Occasional use (n)	Regular use (n)	Heavy use (n)
ECT	11	18	19	3
Non-ECT	12	18	17	4
Non-patient	12	29	5	5

Because the expected frequency of heavy users is less than 5, the regular use and heavy use cells were pooled. This resulted in a Chi-square = 4.8, df 2,  $p < .10$ , for the ECT group vs non-patient group comparison, and a Chi-square = 4.1, df 2, not significant, for the non-ECT group vs non-patient group comparison.

Careful note was kept of all types and dosages of medication. Dosages were converted into simple five-point scales using amitriptyline equivalents for antidepressant regimes. The patient groups, whether ECT or non-ECT, received similar mean doses of tricyclic

antidepressants, lithium carbonate, minor tranquillizers, hypnotics, and other antidepressants. (See Table 11)

Table 11. Mean drug dosages of patient groups at initial and follow-up testings.

Group	Type of medication	Initial	Post-ECT	4 months	7 months
ECT	Tricyclic antidepressants	0.7(0.8)	1.0(0.9)	0.9(1.0)	0.8(0.9)
	Lithium carbonate	0.2(0.5)	0.3(0.6)	0.5(0.8)	0.4(0.8)
	Minor tranquillizers	0.1(0.3)	0.1(0.2)	0.1(0.3)	0.1(0.3)
	Night Sedatives	0.4(0.5)	0.3(0.5)	0.3(0.5)	0.2(0.4)
	Other antidepressants	0.2(0.4)	0.3(0.4)	0.3(0.5)	0.2(0.4)
Non-ECT	Tricyclic antidepressants	0.9(0.9)	-	0.7(0.9)	0.7(0.8)
	Lithium carbonate	0.1(0.3)	-	0.2(0.5)	0.2(0.6)
	Minor tranquillizers	0.2(0.4)	-	0.1(0.4)	0.1(0.3)
	Night Sedatives	0.3(0.5)	-	0.3(0.5)	0.3(0.5)
	Other antidepressants	0.3(0.5)	-	0.4(0.5)	0.4(0.5)

(Standard deviations in parentheses.)

The differences in the medication dosages between the two patient groups, for each particular type of psychotropic

drug and at each point of comparison, are not statistically significant.

The two patient groups had two important differences, however. On the Newcastle scale (Carney et al, 1965), the ECT group scored a mean of 6 (s.d. 2.3), and the non-ECT group 4.8 (s.d. 2.4); therefore, the ECT group was more endogenously ill ( $p < .01$ ). (This variable accounts for 5.4% of the total variance between the groups.) Also, the ECT group had received significantly more ECT prior to the index admission than did the non-ECT group, the ECT group receiving a mean of 9.5 (s.d. 9.5) individual treatments, and the non-ECT group receiving a mean of 3 (s.d. 5.7) individual treatments. This variable accounts for 14.8% of the total variance between the groups. (See Table 12.)

Table 12. Number of previous individual ECTs, both patient groups.

<u>Number of ECTs</u>	<u>ECT group</u>		<u>Non-ECT Group</u>	
	<u>Patients</u>	<u>%</u>	<u>Patients</u>	<u>%</u>
0	18	35.3	37	72.6
1-5	11	21.6	7	13.7
6-12	7	13.7	4	7.8
13-20	6	11.8	2	3.9
21-50	7	13.7	1	2.0
51 +	2	3.9	0	0.0

By collapsing the six number of ECTs categories into two categories, patients receiving 0-12 ECTs and patients

receiving 13 or more ECTs, then applying the Fisher Exact Probability Test, shows that the differences in numbers of previous ECTs between the two patient groups is statistically significant ( $p = .002$ ).

Method(C) Pilot Studies

Several pilot studies were mounted between June and October 1977, using non-patient volunteers (n=118) and depressed in-patients (n=34). These studies had the following objectives:

- 1) To ascertain how many of the 138 questions from the Personal Remote Memory test (Bidder et al, 1970) could be asked of a typical depressed patient within 10 minutes, and which questions were too distressing for such patients.
- 2) To devise five parallel forms of the Famous Personalities Test (Stevens, 1979) and to eliminate those names which were unpronounceable. These tasks were accomplished in three stages, with a non-patient group (n=35), a depressed in-patient group (n=34) and a second non-patient group (n=83).
- 3) Four new parallel forms of an auditory/verbal learning test were devised, controlling, by the use of appropriate tables, for the following variables: imagery, concreteness, meaningfulness, and usage frequency. (Paivio, Yuille, and Madigan, 1968.)
- 4) Five new parallel forms of a positional learning test were devised, with particular reference to appropriate administration and number of stimuli.



- 5) To ascertain if the stimuli used for the Visual Design Learning test (Meyer, 1959) and the Cube Analysis Test (Ratcliff, 1970) could be adequately seen by depressed patients. On the basis of this, the Cube Analysis Test stimuli were enlarged to twice their original size.
- 6) Three new parallel forms of the Sentence Repetition Test (Newcombe, 1969) were devised and tested.
- 7) The difficulty level of tests infrequently used with moderately severe depressives (e.g., the Mental Set Shifting Test), was determined.
- 8) The mean, lower and upper duration of each cognitive test, when administered to depressed patients, was determined. (See Table 13.)

Table 13. Mean, lower and upper durations of cognitive tests (in minutes).

<u>Test</u>	<u>Lower duration</u>	<u>Mean duration</u>	<u>Upper duration</u>
Delayed Recall	2.5	3	4
Personal Remote	6.5	7	12
Verbal Learning	4	4.5	6
Positional Learning	7.5	8	9
Logical Memory	1.5	2	2.5
Cube Analysis	2	2	3
Sentence Repetition	3	3	4
Visual Design Learning	5	7	8
Famous Personalities	4.5	5	6
Choice Reaction Time	6	7	8

(Continued)



Table 13. (Continued)

	<u>Lower</u> <u>duration</u>	<u>Mean</u> <u>duration</u>	<u>Upper</u> <u>duration</u>
Incidental Visual Memory	4.5	5	5.5
Verbal Memory	3	3.5	4
Total	49.5	56.5	72
Modal duration		60	

Test durations were not highly correlated, except in profoundly severe cases. Duration partly depended on whether a test was self- or tester-paced. Also, poor performance on one test sometimes contaminated performance on the following test.

- 9) Easily understood instructions, a standard administration procedure and form of words, were devised for each test. Additional standard explanatory instructions, with examples, were devised in case the initial instructions were not understood. (See test formats in Appendix.)
- 10) Familiarization and practice was obtained in administering the tests to the same types of subjects and in the same settings as subjects in the main study.

(D) Procedure

Test administration

Shortly after admission each potential subject was interviewed by a research psychiatrist, who collected background information and rated the subject's type and

severity of depression. Depressive severity and symptomatology were rated independently on each testing occasion using the Hamilton scale, the Wakefield self-rating scale, and a number of visual analogue scales. The research psychiatrist had received formal training and practice in the use of the Present State Examination (Wing, Cooper, and Sartorius, 1974), from which the Hamilton scale is derived.

Cognitive assessment was conducted by the author within 24 hours of the psychiatric interview. The author and the research psychiatrist were blind to each other's assessment; at this stage it was not known whether the patient would receive ECT or chemotherapy. This latter decision was arrived at independently by one of the 17 consultant psychiatrists with clinical responsibility for the patients.

The cognitive tests were administered in a random order to each patient to control for possible order interaction effects. The exceptions to this were the Verbal Learning and Positional Learning tests, which were always presented near the beginning, and the Choice Reaction Test, Incidental Visual Memory Test, and Verbal Memory Test, which were always presented at the end. Visual tests were alternated with tests in the auditory modality. The selection of a particular test order from the 360 possible permutations was by random numbers table (The Rand Corporation, 1955).

There were four complete parallel test batteries (copies in Appendix) administered in counterbalanced order to both patient groups. The selection of a particular order from the 24 possible permutations was by random numbers table. If, for example, a patient in the ECT group was presented four test batteries in the order B-A-C-D, the next consecutive patient in the non-ECT group would be assigned their test batteries in the same order. A periodic check was maintained on test battery ordering.

Counterbalancing was strictly observed to control possible differential inter-battery interaction effects, and to smoothe out any minor deviations remaining between parallel forms.

Diurnal mood variation, with its possible effects on cognitive function, was controlled in several ways. Although it was not possible to test all patients at the same time of day (due to the number of patients involved and differences in ward routines), equivalent proportions of patients in each group were tested at various periods throughout the day. (See Table 14.) The afternoon periods were preferentially selected to minimize the effects of the patients' disturbance. At followup, patients were always tested at the same time of day as they were at the initial session.

Table 14. Diurnal distributions of assessments.

Group	Time of Day			
	0900-1200	1201-1500	1501-1800	1801-2030
ECT	9	18	13	11
Non-ECT	10	16	16	9
Non-patient	9	15	13	14

Differences in these diurnal distributions are not statistically significant.

#### ECT administration

ECT was given twice-weekly using an Ectron Mark IV machine. All patients received a bi-directional modified sine wave current of 50 Herz at a preset stimulus duration of 1.5 seconds. The actual amount of current delivered depends on the inter-electrode resistance, viz., the resistance of the subject's head. This may vary from subject to subject but for a typical resistance of 470 ohms, the Ectron Mark IV delivers 36 joules of current. In bilateral ECT, 90% to 99% of the voltage drop takes place in the skin, galea, and osseous tissue (Smith and Wegener, 1944; Volavka, 1972). The standard bitemporal electrode placement (4 cms perpendicularly above the mid-point of an imaginary line drawn from the external auditory meatus to the lateral angle of the eye) was used

for bilateral ECT. The current was passed across both hemispheres, running mainly through the temporal and frontal lobes. Current flow through the brain is very diffuse. The current does not flow as in an entirely homogeneous conductor, but principally along neuronal paths, such as the corpus callosum (Lorimer, Segal, and Stein, 1949). The fluid in the cerebral ventricles offers less resistance, and the blood vessels act as better conductors than the cerebral parenchyma (Hartelius, 1952).

For unilateral ECT to the non-dominant cerebral hemisphere, the position of Lancaster, Steinert, and Frost (1958), was used. Cerebral dominance was inferred from laterality. Only right-handed patients were allocated to the unilateral ECT group. Table 15 shows the number of treatments received by the patients assigned to either bilateral or unilateral treatment.

Table 15. Number of ECTs received by patients in bilateral or unilateral treatment.

Number of ECTs	Bilateral group (n=34)	Unilateral group (n=17)
2	1	0
3-4	6	2
5-6	18	6
7-8	2	6
9-10	3	3
11 or more	4	0

By collapsing the number of treatment categories into two

categories, 6 treatments or less, and 7 treatments or more, shows that the differences between the bilateral and unilateral groups on number of ECTs was not statistically significant ( $\text{Chi-Squared} = 3.47$ ,  $\text{df } 1$ ).

All ECT patients were fasted from the evening before each treatment, and premedicated with atropine sulphate 0.6 mg, 30 to 40 minutes before ECT, in order to dry up secretions. All ECT patients received sodium thiopentone 150 to 300 mg as a muscle relaxant. These latter two medications were administered by an anaesthetist. Patients were always well oxygenated immediately before the treatment was applied.

In all but one patient, signed voluntary consent for ECT had been obtained.

#### (E) Design

##### 1. Normative studies

As three of the cognitive tests used in this research were new, i.e., the Positional Learning Test, Incidental Visual Memory Test, and the Verbal Memory Test, they needed validation. There were no published reliability estimates for several other tests, e.g., Cube Analysis, Sentence Repetition; these omissions were in need of correction. One other criterion for the research tests was objectivity. Since inter-rater agreement contributes importantly to objectivity, this required analysis.

To accomplish these aims, a large group ( $n=164$ ) of volunteers were administered the cognitive test battery in exactly the same manner as the patient samples. Pearson product-moment correlation coefficients were computed for each test with every other test. One goal of this was to ascertain how highly the new tests correlated with established tests. To determine the factor structure of the cognitive test battery, a principal components analysis was also undertaken.

A random sample ( $n=51$ ) of volunteer subjects were re-tested with parallel forms after a period of time comparable to the re-test intervals of the patient groups; the mean re-test interval was 6 months (mode and median 5 months; range 3 - 15 months). The goals of this study were to ascertain the equivalence of the parallel tests, how stable the test scores would be after the interval, and to calculate test-retest reliability coefficients.

A random sample of one hundred test protocols were scored blindly by two clinical psychologists provided with written scoring instructions. (Instructions were obviated by some of the tests, such as the Choice Reaction Time Test, in which the scores were obtained by averaging direct digital measurements). The goal of this study was to ascertain the level of interscorer agreement for each test.



2. Controlled study: ECT vs non-ECT group comparisons

The results of each patient group on each cognitive test were compared from three comparison points: prior to treatment, at 4 months and at 7 months after the first assessment. Further, the ECT group was tested one week after the completion of the ECT course. (See Figure A.)

Figure A. Timing and Frequency of Testing

	Pre-ECT testing	Post-ECT testing	4 month testing	7 month testing
ECT group	<u>ECT</u>	X	3 months	3 months
Non-ECT group		4 months		3 months

X = one week

For all comparisons between the patient groups independent Student t tests (two-tailed) were used. Dependent Student t tests (two-tailed) were used for all comparisons within the same group.

3. Controlled study: Unilateral vs bilateral ECT group comparisons

From the 34 patients who received bilateral ECT, 15 were blindly matched individually to 15 of the 17 patients who had received unilateral nondominant ECT. (See Table 16.)

Table 16./

Table 16. Matching of bilateral ECT group with unilateral non-dominant ECT group.

Variable	Unilateral ECT group (n = 15)		Bilateral ECT group (n = 15)	
	Mean	SD	Mean	SD
Age	50.3	14.4	52.3	13.2
Social Class	2.9	1.3	3.1	1.3
Educational Level	11.7	3.4	11.2	3.4
Verbal Intelligence	101.1	12.6	101.7	15.4
Number of ECT	7.3	2.1	7.3	2.3
Sex Distribution	10 females: 5 males		10 females: 5 males	

Note: There were also no significant differences on smoking and drinking habits, physical illnesses, ECT complications, Newcastle diagnostic index or treatment prediction indices, laterality, non-verbal intelligence, severity of depression, neurotic symptoms, and drug regimes at any test period.

The results of the bilateral ECT group and the unilateral ECT group on each cognitive test were compared prior to treatment, one week after completion of the ECT course, at 4 months and at 7 months after the first assessment. Dependent Student t tests (two-tailed) were used for all comparisons between and within these groups.

ResultsNormative Studies1) Test validity

Table 17. sets out the correlations of each of the three new tests with the other tests in the battery that have previously been validated.

Table 17. Correlations between new tests and validated tests.

Test	Positional Learning	Incidental Visual Memory	Verbal Memory
Delayed Recall	+ .29 ***	+ .37 ***	+ .13 n.s.
Delayed Recognition	+ .15 n.s.	+ .14 n.s.	+ .17 *
Personal Remote	+ .02 n.s.	+ .25 **	+ .08 n.s.
Logical Memory	+ .45 ***	+ .16 *	+ .22 **
Famous Personalities	+ .30 ***	+ .20 *	+ .12 n.s.
Sentence Repetition	+ .32 ***	+ .35 ***	+ .20 *
Verbal Learning	+ .44 ***	+ .34 ***	+ .14 n.s.
Visual Design Learning	+ .57 ***	+ .25 **	+ .29 ***
Decision Time	+ .38 ***	+ .22 **	+ .08 n.s.
Cube Analysis errors	+ .39 ***	+ .14 n.s.	+ .12 n.s.
Cube Analysis time	+ .16 *	+ .11 n.s.	+ .07 n.s.

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .001$

n.s. not significant

(n=164)

Each new test was also referenced to an independent and valid mode of investigation, i.e., computerised axial tomography (CAT scan). The cognitive test battery was administered by the author to a heterogeneous group of inpatients (n=33) at the Royal Edinburgh Hospital. (See Table 18.) These patients had been referred for psychometric assessment. Usually within one to two weeks these patients were also referred to the Department of Surgical Neurology, Western General Hospital, for a CAT scan. The final diagnoses of these patients were as follows: dementia (7), Korsakof's psychosis (7), cerebrovascular accident (4), anoxic brain damage (2), arteriosclerotic dementia (1), syphilis of the CNS (1), encephalitis (1), cerebral tumour (1), depression (5), schizophrenia (2), and hypomania (1). The consultant neuroradiologist classified the CAT scan appearance of each patient's brain into five global categories: normal, minor changes, mild, moderate, or moderately severe deterioration. The radiologist's assessments were based on a combination of degree of cortical atrophy and degree of ventricular dilatation. The five severity categories were converted into a 5-point scale for statistical analysis.

Table 18/

Table 18. Descriptive variables and test scores of patients referred for psychometrics and neuroradiology.

Variable

Social Class (numbers)	I 4	II 1	III 12	IV 7	V 9
Sex distribution (numbers)	<u>Male</u> 19		<u>Female</u> 14		
CAT scan severity (numbers)	<u>Normal</u> 7	<u>Minor</u> 10	<u>Mild</u> 4	<u>Moderate</u> 5	<u>Severe</u> 7
	<u>Mean</u>		<u>s.d.</u>		
Age	50.8		16.7		
Educational Level (years)	10.0		2.0		
Verbal Memory, sensitivity	3.1		1.9		
Visual Incidental Memory	8.6		3.8		
Positional Learning	40.6		25.7		

The correlations between CAT scan severity and age, education, and social class were not statistically significant.

All three cognitive tests were very significantly correlated with structural cerebral abnormalities as ascertained by CAT scan (See Table 19.).

Table 19. Correlations between CAT scan severity and psychometric tests.

	Verbal Memory, sensitivity	Visual Incidental Memory	Positional Learning
CAT scan severity	- .64 ***	- .70 ***	+ .59 ***

\*\*\*  $p < .001$

Due to the heterogeneous nature of this patient group, the

data on Verbal Memory response bias cannot be soundly interpreted.

## 2) Principal Components Analysis

Data from the community volunteer sample (n=164) for the tests used in the patient studies were submitted to a principal components analysis, Varimax rotation. Five significant factors, accounting respectively for 16.4%, 14.0%, 11.7%, 6.7% and 6.7% of the variance in the test battery, were identified. (See Table 20.)

Table 20. Varimax rotated factor loadings, cognitive tests.

<u>Test</u>	<u>Factor I</u> <u>Learning</u>	<u>Factor II</u> <u>Psychomotor</u> <u>Speed</u>	<u>Factor III</u> <u>Retrieval</u>	<u>Factor IV</u> <u>Recognition</u>	<u>Factor V</u> <u>Subjective</u> <u>Complaints</u>
Logical Memory	- .71	+ .01	+ .11	+ .01	- .13
Positional Learning	+ .68	+ .35	- .13	- .02	0
Visual Des- ign Learning	+ .66	+ .29	- .16	+ .03	0
Verbal Memory	- .59	+ .08	- .08	- .25	+ .24
Cube Analysis, errors	+ .53	+ .21	- .09	- .12	+ .26
Verbal Learning	+ .42	+ .39	- .34	- .15	- .04
Fluid Movement	+ .05	+ .75	- .05	+ .09	- .16
Decision Time	+ .15	+ .72	- .16	- .03	+ .17
Cube Analysis, time	+ .03	+ .63	- .09	+ .53	- .21
Movement Time	+ .28	+ .54	- .16	- .20	+ .18

(Continued)



Table 20. (Continued)

<u>Test</u>	<u>Factor I</u> <u>Learning</u>	<u>Factor II</u> <u>Psychomotor</u> <u>Speed</u>	<u>Factor III</u> <u>Retrieval</u>	<u>Factor IV</u> <u>Recognition</u>	<u>Factor V</u> <u>Subjective</u> <u>Complaints</u>
Personal Remote	+ .16	+ .13	+ .71	+ .06	- .31
Incidental Visual Memory	- .12	- .16	+ .69	- .01	+ .19
Delayed Recall	- .31	- .27	+ .58	- .13	- .03
Sentence Repetition	+ .39	+ .17	- .51	+ .04	- .22
Delayed Recognition	- .23	- .02	+ .33	- .65	+ .02
Famous Personal- ities	- .36	- .22	+ .22	+ .51	+ .25
Cognitive Failures Question- naire	+ .08	+ .04	+ .05	+ .06	+ .78

### 3) Reliability, stability, interscorer agreement

To ascertain the reliability and stability of the tests in this study, a random sample (n=51) of the non-patient volunteer subjects were re-tested after a mean interval of 23 weeks (range 11-52 weeks). (See Table 21.)

Table 21. Characteristics of re-tested subjects.

<u>Variable</u>	<u>Mean</u>	<u>s.d.</u>
Age (years)	51.2	11.7
Education (years)	10.9	1.7
Verbal Intelligence	104.2	8.7
Non-Verbal Intelligence	101.5	13.2

(Continued)



Table 21. (Continued)

Social class distribution (numbers)				
I	II	III	IV	V
8	9	28	4	2
Sex distribution (numbers)				
Males		5	Females	
			46	

Table 22 lists the test-retest reliability of each test, scores on each test on both test occasions, the Dependent t based on the comparison between these test occasions, and the average percentage of interscorer agreement.

Table 22. Test reliability, stability, and interscorer agreement data.

<u>Test</u>	<u>Test-retest reliability</u>	<u>Score- Time 1</u>	<u>Score- Time 2</u>	<u>Depen- dent t</u>	<u>Average Inter- scorer Agreement</u>
Laterality	.96***	10.1	10.1	n.s.	98%
Delayed Recall	.54***	5.8	6.1	n.s.	99%
Delayed Recognition	.78***	8.7	8.7	n.s.	99%
Personal Remote	.58***	22.8	21.9	2.9**	93%
Logical Memory	.53***	14.4	15.3	n.s.	96%
Famous Personalities					
1930s	.86***	8.9	9.2	n.s.	98%
1940s	.78***	9.7	9.1	n.s.	98%
1950s	.66***	11.6	11.9	n.s.	98%
1960s	.73***	14.5	14.5	n.s.	99%
1970s	.73***	16.4	16.3	n.s.	99%
Fictitious Personalities	.45***	1.5	1.5	n.s.	95%
Famous Personalities total score	.86***	59.1	59.2	n.s.	99%

(Continued)

Table 22. (Continued)

<u>Test</u>	<u>Test-retest reliability</u>	<u>Score- Time 1</u>	<u>Score- Time 2</u>	<u>Depen- dent t</u>	<u>Average Inter- scorer Agreement</u>
Cube Analysis, errors	.43**	13.6	9.7	2.0*	96%
Cube Analysis, time	.91***	6.2	5.8	n.s.	98%
Sentence Repetition	.86***	6.4	6.7	n.s.	97%
Positional Learning	.71***	16.7	16.9	n.s.	97%
Verbal Learning	.52***	23.1	23.5	n.s.	97%
Visual Design Learning	.76***	19.3	19.7	n.s.	98%
Decision Time	.52***	349.9	375.0	n.s.	100%
Movement Time	.56***	279.8	298.6	n.s.	100%
Fluid Move- ment Time	.66***	12.9	12.3	n.s.	99%
Verbal Memory, sensitivity	.35*	4.3	4.2	n.s.	100%
Verbal Memory, response bias	.35*	0.4	0.7	n.s.	100%
Verbal Memory, true posi- tives	.65***	5.8	5.8	n.s.	100%
false posi- tives	.37**	0.9	0.8	n.s.	100%
semantic errors	.25 n.s.	0.6	0.6	n.s.	100%
structural errors	.57***	0.3	0.2	n.s.	100%
Incidental Visual Memory	.36*	12.2	13.0	2.4*	96%
Face-Name Memory	.57**	8.9	9.5	n.s.	100%
Cognitive Failures Questionnaire	.82***	65.2	68.6	n.s.	100%
Mental Set Shifting Test, errors	.43**	2.4	1.6	2.5*	96%
time	.89***	53.6	48.7	5.0***	99%
correct alter- nations	.59***	1.6	1.8	2.4*	97%

(Continued)

Table 22. (Continued)

<u>Test</u>	<u>Test-retest</u> <u>reliability</u>	<u>Score-</u> <u>Time 1</u>	<u>Score-</u> <u>Time 2</u>	<u>Depen-</u> <u>dent</u> <u>t</u>	<u>Average</u> <u>Inter-</u> <u>scorer</u> <u>Agreement</u>
Wakefield Self-Rating Scale	.78***	8.0	10.0	4.3***	100%
Visual Ana- logues,					
tense-relaxed	.76***	75.6	66.4	3.5**	100%
sad-happy	.66***	69.7	67.7	n.s.	100%
worst-best	.43**	59.0	59.6	n.s.	100%

\*\*\*  $p < .001$ \*\*  $p < .01$ \* $p < .05$ 

The recorded test-retest reliabilities represent under-estimates, as they were based on comparisons of randomly selected parallel forms. The reliability of the tests are sufficiently high for use in research involving large group comparisons. The Verbal Memory Test is adversely prone to between-occasion and between-test variability in semantic false positives.

Significant forgetting in personal remote memory was demonstrated on retesting the same subjects. Three tests - Cube Analysis, Incidental Visual Memory, and the Mental Set Shifting Test - are susceptible to practice effects, despite the use of parallel forms in the case of Cube Analysis and Incidental Visual Memory. All tests possessed more than satisfactory levels of interscorer reliability.

## Results

### B) Controlled study: ECT vs non-ECT group comparisons

Due to the large number of test comparisons, results will only be reported in this section when the difference in results produced a P value of  $P < .10$ . It can therefore be assumed that all scores on tests not recorded in this section did not even approach significance.

The mental status of both the ECT and the non-ECT groups improved significantly. All of the ECT group's improvement occurred over the course of their ECT; their Hamilton and Wakefield scores fell from  $26.6 \pm 1.0$  and  $25.0 \pm 1.0$  to  $11.6 \pm 1.3$  and  $13.9 \pm 1.3$  respectively over a period of  $25 \pm 2$  days. This improvement was maintained at 4 months and at 7 months. The non-ECT group were not tested again until 4 months after the initial assessment and by that time their depression had improved as much as the ECT group. This improvement was maintained at 7 months. There were no differences in depression scores between the two patient groups at 4 months or 7 months. (See Table 23.). According to the Wakefield scale, the clinically recovered patient groups tended to be more depressed than the normal control group. While this difference was statistically significant, the strength of this difference was weak. For instance, depressive severity accounted for only 9% of the variance between the normal control group and the two patient groups at 4 months, and 7% at 7 months.

Table 23. Comparison of Wakefield scores between normal control group and patient groups at followup.

	Normal Controls (n=51)	ECT group/ 1 week (n=51)	ECT group/ 4 months (n=45)	ECT group/ 7 months (n=41)	Non-ECT group/ 4 months (n=47)	Non-ECT group/ 7 months (n=46)
*Wakefield mean	10.6	13.9	14.4	12.8	14.9	15
s.d.	6.5	9.1	10.5	9.7	9.2	8.9
range	1-31	0-35	0-36	0-35	0-32	0-34

---

*The published normal mean value for this self-rating scale is 6.2 (n=200)(Snaith et al, 1971)	Normal controls vs ECT group/4 months vs non-ECT group/4 months		Normal controls vs ECT group/7 months vs non-ECT group/7 months.	
	F = 3.26, df = 2,140 p < .05 % variance 8.8%		F = 3.16, df = 2,135 p < .05 % variance 7.2%	

---

Normal controls vs ECT group/1 week	Normal controls vs ECT group/4 months	Normal controls vs non-ECT group/4 months	Normal controls vs ECT group/7 months	Normal controls vs non-ECT group/7 months
t = 2.14	t = 2.10	t = 2.65	t = 1.27	t = 2.75
p < .05	p < .05	p < .01	p = n.s.	p < .01
% variance 3.3%	% variance 3.4%	% variance 5.4%	% variance 0.7%	% variance 6.5%

Details of the initial testing are given in Table 24. The group that went on to receive ECT started out in the study significantly more impaired than the non-ECT group on 9 out of the 24 possible cognitive test score comparisons. There were only two tests in which the ECT group began the study with a slightly better score than the non-ECT group. The former group made slightly fewer errors in the Positional Learning Test and falsely recognised slightly fewer fictitious names on the Famous Personality Test; these differences were not statistically significant.

Table 24. Initial differences between the two patient groups.

Test	Normal level		ECT group		Non-ECT Group		Statistical significance (of difference between ECT and non-ECT groups)
	Mean	SD	Mean	SD	Mean	SD	
Famous personalities, 1970s	15	2.8	12.3	4.7	15.2	3.8	$p < .001$
Delayed recall	5.5	1.6	4.4	1.9	5.5	1.4	$p < .001$
Delayed recognition	8.5	0.9	7.3	1.9	8.2	1.0	$p < .001$
Verbal memory, semantic false positives	0.94	1.0	1.23	1.0	0.76	0.7	$p < .05$
Verbal learning	26	7.0	38	18.6	31	12.9	$p < .05$
Decision time (milliseconds)	387	128	599	337	483	183	$p < .05$
Personal remote memories	21.5	2.5	20.1	4.1	21.7	2.6	$p < .05$
Movement time (milliseconds)	295	114	593	552	425	213	$p < .05$
Fluid movement (seconds)	13.8	3.8	20.4	9.4	16.8	8.5	$p < .05$

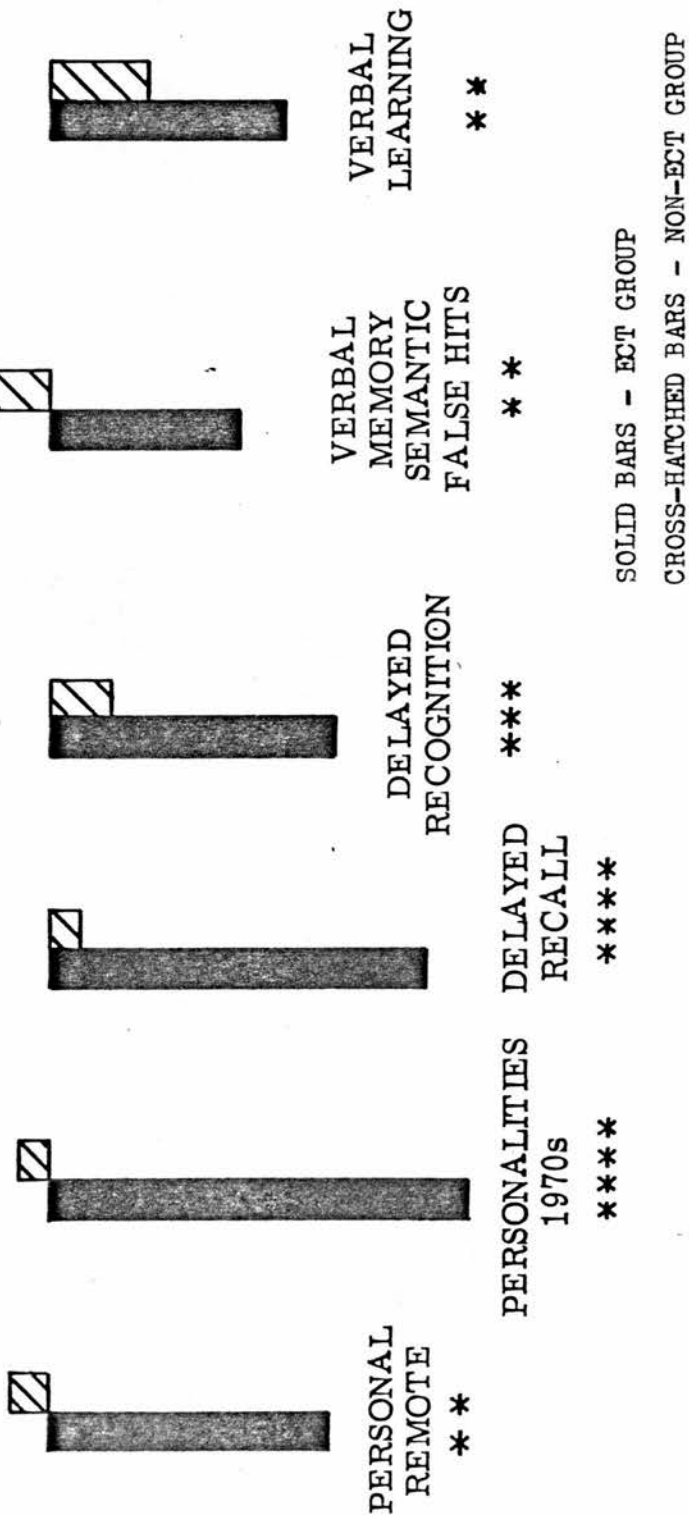
(Continued)

# PRE-TREATMENT COMPARISON

\*\* P<.05  
 \*\*\* P<.01  
 \*\*\*\*\* P<.001

These bar graphs represent  
 mean score differences from  
 the normal population mean  
 scores

142.a.

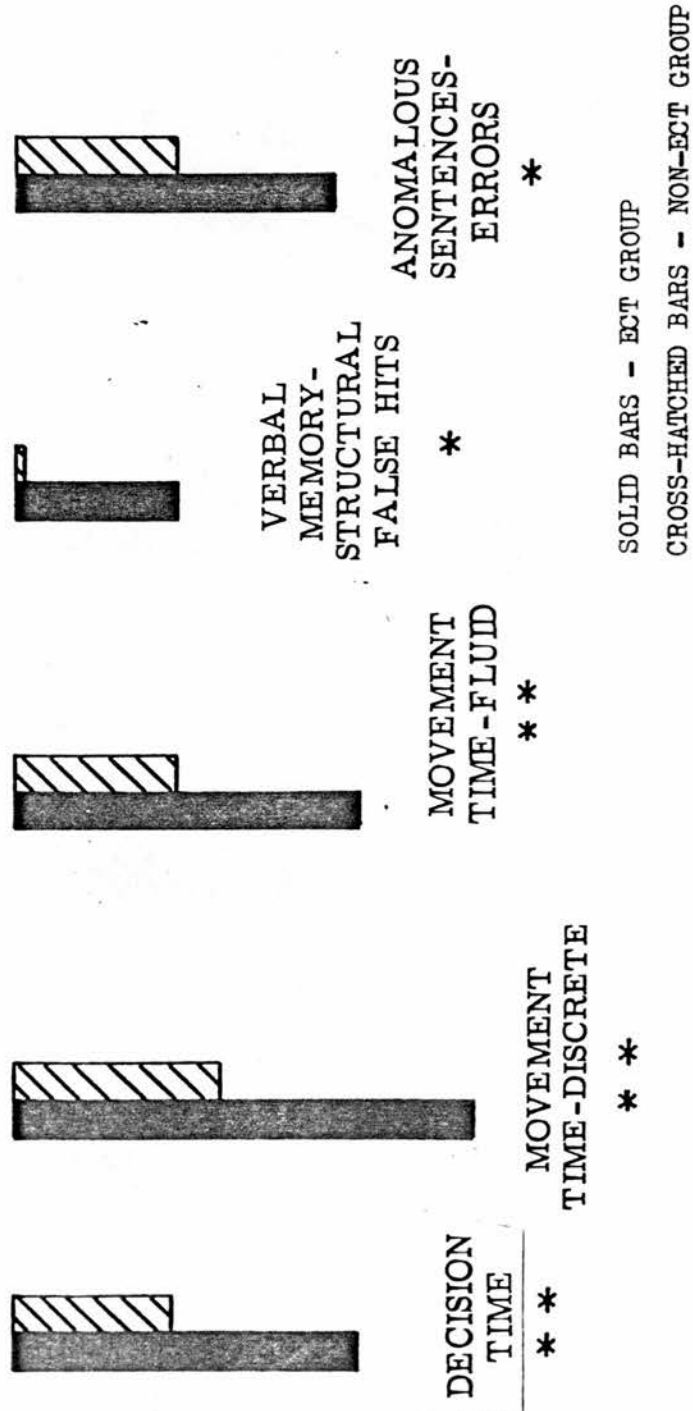


142.a.



# PRE-TREATMENT COMPARISON

\* P < .10  
 \*\* P < .05



142.b.

142.b.

PRE-TREATMENT COMPARISON

\* P < .10

\*\*\*\* P < .001

\*\*\*\* P < .01

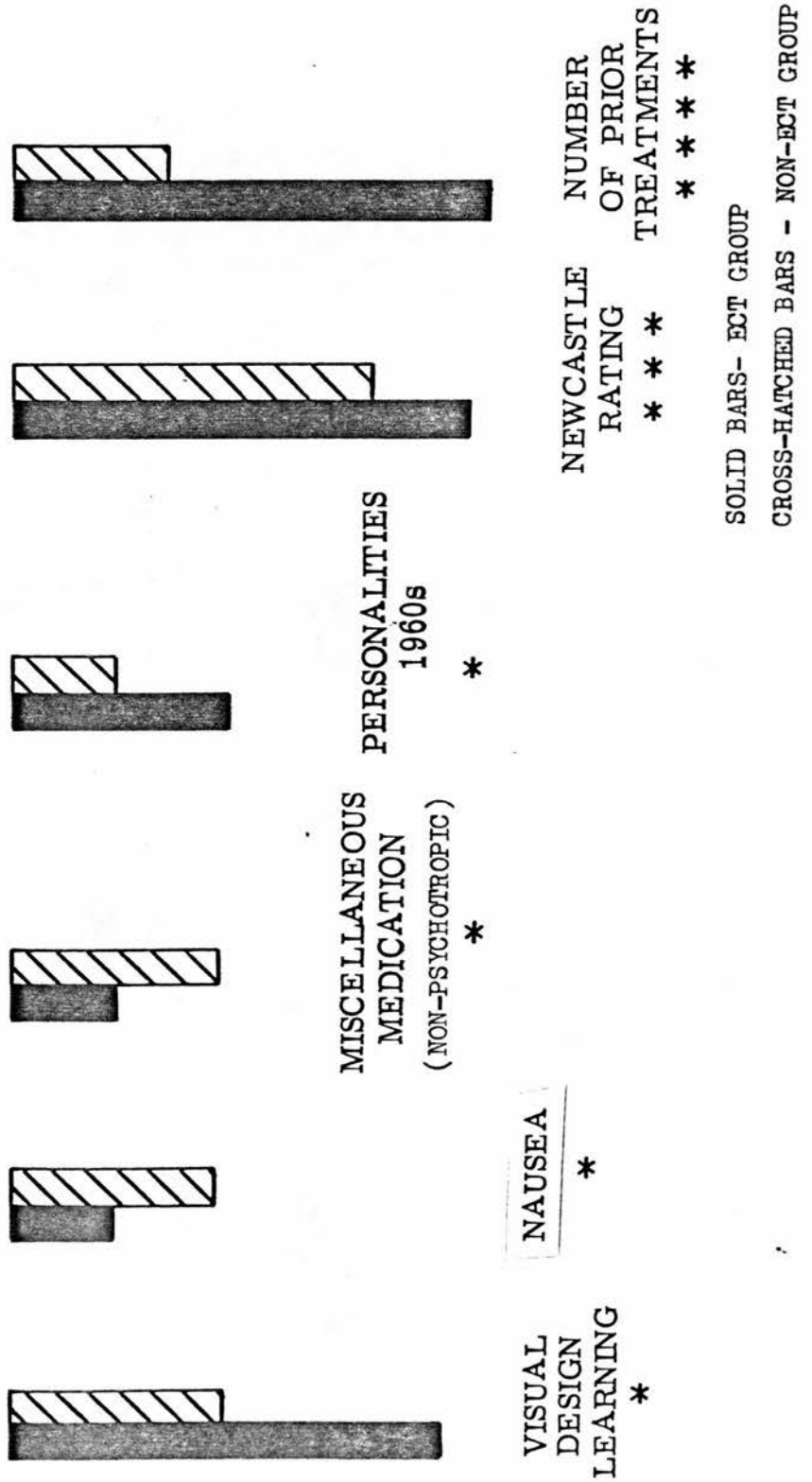


Table 24. (Continued)

Test	Normal level		ECT group		Non-ECT Group		Statistical significance (of difference between ECT and non-ECT groups)
	Mean	SD	Mean	SD	Mean	SD	
Verbal memory, structural false positives	0.33	0.60	0.61	0.85	0.33	0.50	$p < .10$
Sentence repetition (errors)	8.7	6.0	14.7	9.7	11.35	7.8	$p < .10$
Visual design learning	21.8	11.2	33.2	18	27.5	14.8	$p < .10$
Famous personalities, 1960s	13.2	3.2	10.4	4.6	11.9	4.7	$p < .10$

The number of previous ECTs that the ECT group had received prior to the index depressive episode was poorly correlated with impaired cognitive performance at the initial testing. Only three cognitive test scores - Famous Personalities, 1970s ( $r = -.48$ ,  $p < .001$ ), Verbal Memory ( $r = -.32$ ,  $p < .05$ ), and Famous Personalities, 1950s ( $r = -.30$ ,  $p < .05$ ) - were significantly correlated with cumulative previous ECT. By contrast, depressive severity was significantly correlated with poor performance on six cognitive tests. Endogenous depression, as measured by the Newcastle index, was even more highly correlated with eleven of the cognitive tests. (See Table 25.)

Table 25. Significant correlations between Hamilton Rating Scale, Newcastle diagnostic rating, and cognitive function tests, ECT group at initial assessment.

<u>Cognitive Test</u>	<u>Correlation with Hamilton</u>	<u>Correlation with Newcastle</u>
Verbal Learning	n.s.	+ .60 ***
Personal Remote Memory	- .59 ***	- .40 **
Logical Memory	n.s.	- .49 **
Visual Design Learning	+ .33 *	+ .42 **
Decision Time	+ .40 **	+ .33 *
Delayed Recall	- .31 *	- .39 **
Cube Analysis, errors	n.s.	+ .35 *
Positional Learning	n.s.	+ .33 *
Movement Time	+ .29 *	+ .33 *
Delayed Recognition	+ .28 *	- .31 *
Cube Analysis, time	n.s.	+ .28 *

(Note. All correlations indicate that depressive severity and endogenous features are associated with cognitive dysfunction.)

\*\*\*  $p < .001$

\*\*  $p < .01$

\*  $p < .05$

The non-ECT group was not quite so impaired relative to the normal control group as was the ECT group relative to the non-ECT group. The non-ECT group began the study significantly more impaired than the normal group on 7 out of the 24 test score comparisons (See Table 26.). All but one of these tests (Logical Memory) were among those that discriminated the ECT group from the non-ECT

group. There were no tests on which the non-ECT group performed better than the normal control group.

The number of ECTs that the non-ECT group had previously received was very weakly related to their cognitive performance at the initial testing. Only two cognitive test score decrements - Incidental Visual Memory ( $r = -.38, p < .01$ ) and Positional Learning ( $r = +.32, p < .05$ ) - were significantly correlated with cumulative previous ECT. Subjective memory complaints, as measured by the Cognitive Failures Questionnaire (CFQ), were significantly, but inversely, correlated with the number of previous ECTs ( $r = -.39, p < .01$ ). In contrast to the ECT group, depressive severity was significantly correlated to poor performance on only one cognitive test, Cube Analysis, time score ( $r = +.31, p < .05$ ), and with increased complaints on the CFQ ( $r = +.29, p < .05$ ). In the non-ECT group, type of depression, as measured by the Newcastle index, was unrelated to cognitive performance.

The ECT group began the study markedly impaired relative to the non-patient group, significantly deficient on 14 of the 24 test comparisons. There were also non-significant trends ( $p < .10$ ) toward impairment on Verbal Memory (structural false positives) and Famous Personalities, 1950s. The tests on which there were no significant differences between the ECT group and the non-patient control group were: Famous Personalities of

the 1930s and 1940s, Fictitious Names, Positional Learning, Cube Analysis (errors), Incidental Visual Memory, and Verbal Memory (semantic false positives).

For both patient groups, if their performance levels relative to the normal level (as a percentage of the normal level) are averaged across all test scores, the ECT group performed 31% worse than the normal level and the non-ECT group performed 11% worse than the normal level. For further comparison, the results of 31 patients with verified mild brain syndromes were also analysed. After controlling for the differential effects of age, social class, and educational level, this analysis indicated that their performance was  $87\% \pm 5\%$  below the normal level. The performance of the patients with functional psychiatric disorders was better than the patients with organic brain syndromes on every test. However, the patients in the ECT group before treatment were nearly as severely impaired as the organic brain syndrome patients on three tests - Cube Analysis (time), Movement Time, and Sentence Repetition.

Table 26./

Table 26. Differences between the normal control group and the non-ECT group (pre-treatment).

Test	Normal Level		Non-ECT group		Statistical Significance
	Mean	SD	Mean	SD	
Movement Time (milliseconds)	295	114	425	213	$p < .001$
Decision Time (milliseconds)	387	128	483	183	$p < .01$
Verbal learning	26	7.0	31	12.9	$p < .05$
Fluid Movement (seconds)	13.8	3.8	16.8	8.5	$p < .05$
Visual design learning	21.8	11.2	27.5	14.8	$p < .05$
Logical Memory	13.4	3.6	11.7	4.3	$p < .05$
Sentence Repetition (errors)	8.7	6.0	11.35	7.8	$p < .05$
Cube Analysis (seconds)	6.4	4.3	9.5	10.6	$p < .10$
Positional Learning	26.1	16.8	20.8	13.8	$p < .10$

The ECT group received a mean course of 7.2 treatments. Although the range was wide, one person receiving only two treatments and one as many as twenty treatments, most patients (63%) received between 5 and 8 treatments. (See Table 15., Methods section.)

There were no complications during treatment involving the study patients, though three patients required a second convulsive stimulus on one occasion each before having a satisfactory fit.



ECT group one week after treatment

Contrary to expectations, the ECT group did not perform worse on any test after treatment than they had beforehand. (There were minute decrements on the Personal Remote Memory test, Famous Personalities, 1970s, and Incidental Visual Memory Test.) In fact, they improved significantly on visual design learning, on measures of psychomotor speed, on immediate repetition of anomalous sentences, and on the cube analysis test. Their verbal memory was also significantly more accurate, in that they committed themselves to fewer semantic false positives. The improvements on visual design learning and the fewer semantic false positives in verbal memory brought the ECT group into the normal range for these tests. (See Table 27.) Two other test scores - Famous Personalities, 1950s and Verbal Memory, structural false positives - also came more definitely into the normal range.

Thus ECT had not produced any further impairment in cognitive function; for instance, on a three-point side-effects scale there was a small rise from a mean of  $1.4 \pm 0.2$  to  $1.65 \pm 0.2$ , indicating that the patients felt their memory to be slightly, but not significantly, more impaired after ECT than before. However, on the same type of scale there was a very significant indication that their subjective confusion was felt to be largely dispelled, falling from  $1.22 \pm 0.2$  to  $0.65 \pm 0.1$ . The number of individual treatments in each patient's ECT

course bore no relationship to his cognitive function one week after treatment. This was the case for the ECT group overall, or if the data for those patients receiving bilateral or unilateral ECT were examined separately. The single significant correlation between number of treatments and the cognitive tests indicated that more treatments were related to improved performance on the Incidental Visual Memory Test ( $r = + .29$ ,  $p < .05$ ).

Those patients whose long-term memory, both for personal and impersonal information, was more intact after ECT, also were those who responded better to the treatment. The correlations between depressive severity one week after treatment and the Personal Remote Memory Test was  $- .29$ ,  $p < .05$ , and  $- .30$ ,  $p < .05$  for the Famous Personality Test.

Four other variables predicted a good response to ECT one week after treatment - age, social class, verbal intelligence, and phobic fear. The correlations between these variables and depressive severity at one week following treatment were as follows: age,  $- .40$ ,  $p < .01$ ; social class,  $+ .37$ ,  $p < .01$ ; verbal intelligence,  $+ .38$ ,  $p < .01$ ; phobic fear, as reported on the Middlesex Hospital Questionnaire (MHQ),  $+ .28$ ,  $p < .05$ . In other words older patients responded better, patients from better socio-economic backgrounds responded better, patients who were more verbally intelligent responded better, and patients who had higher scores on MHQ Phobic Fear responded less well to ECT.

Despite the alleviation of their depressive illnesses, this group at this point had significantly poorer scores than the normal control group on twelve tests (See Table 28.). If the ECT group's performance levels relative to the normal level (as a percentage of the normal level) were averaged across all test scores, they performed on average 10% below the normal level on this occasion.

Table 27. ECT group-comparison of measures before and one week after treatment.

<u>Variable</u>	<u>Before ECT</u>		<u>After ECT</u>		<u>Statistical signifi- cance</u> (2- tailed)	<u>Normal level</u>	
	<u>Mean</u>	<u>s.d.</u>	<u>Mean</u>	<u>s.d.</u>		<u>Mean</u>	<u>s.d.</u>
Visual design learning	33.2	18.0	26.0	11.3	p < .01	21.8	11.2
Decision Time (milliseconds)	599	337	455	161	p < .01	387	128
Movement Time (milliseconds)	593	552	404	205	p < .01	295	114
Verbal Memory, false positives	1.24	1.03	0.71	0.96	p < .01	0.94	0.97
Sentence repetition	14.7	9.67	12.1	8.22	p < .05	8.72	6.00
Cube analysis (errors)	18.3	16.1	13.8	13.0	p < .05	16.0	14.7
Positional learning	25.0	13.6	20.7	10.9	p < .05	20.8	13.8
Cube analysis (time, in seconds)	12.2	13.0	9.04	6.00	p < .10	6.39	4.32
Delayed Recognition	7.29	1.91	7.88	1.23	p < .10	8.53	0.90

(Continued)

Table 27. (Continued)

<u>Variable</u>	<u>Before ECT</u>		<u>After ECT</u>		<u>Statistical</u> <u>signifi-</u> <u>cance</u>	<u>Normal level</u>	
	<u>Mean</u>	<u>s.d.</u>	<u>Mean</u>	<u>s.d.</u>	( <u>2-</u> <u>tailed</u> )	<u>Mean</u>	<u>s.d.</u>
Subjective side effects							
- Confusion	1.22	1.17	0.65	0.97	p < .01	_____	_____
- Dizziness	0.84	0.94	0.63	0.83	p < .10	_____	_____

(On all other cognitive tests the ECT group did not change significantly.)

Table 28. ECT group - tests in deficit one week after treatment relative to the non-patient control group.

<u>Test</u>	<u>ECT group</u>		<u>Normal level</u>		<u>Statistical</u> <u>significance</u>
	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>	
Famous Personalities					
1960s	10.6	4.6	13.2	3.2	p < .001
1970s	11.9	5.2	15	2.8	p < .001
Verbal Learning	33.5	14	26.1	7	p < .01
Delayed Recall	4.5	1.9	5.5	1.6	p < .01
Delayed Recognition	7.9	1.2	8.5	0.9	p < .01
Movement Time (milliseconds)	404	205	295	114	p < .01
Personal Remote Memories	20	3.5	21.5	2.5	p < .05
Cube Analysis (seconds)	9	6	6.4	4.3	p < .05
Sentence Repetition	12.1	8.2	8.7	6	p < .05
Decision Time (milliseconds)	455	161	387	128	p < .05
Incidental Visual Memory	10.4	2.8	11.3	2.1	p < .10
Logical Memory	12	4.7	13.4	3.6	p < .10

ECT group and non-ECT group cognitive test comparisons at  
at four months

When the ECT and non-ECT groups were compared at this stage (see Table 29.), their scores on nearly all the cognitive tests were very similar. Only two tests distinguished between the groups at a significance level of 5 per cent or less. The ECT group were not able to remember the names of famous personalities from the decade 1970-79 as well as the non-ECT group, but they did significantly better on the correct alternation measure of the mental set shifting test.

Table 29. ECT group vs non-ECT group at four months.

Test	<u>ECT group</u>		<u>Non-ECT group</u>		<u>Statistical sig-nificance</u>	<u>Normal Level</u>	
	Mean	s.d.	Mean	s.d.		Mean	s.d.
Famous personalities, 1970s	12.9	5.2	15.4	3.7	$p < .01$	15	2.8
Mental set-shifting, correct alternations	1.53	0.6	1.2	0.7	$p < .05^*$	1.4	0.6
Sentence repetition, (errors)	13.8	8.0	10.8	6.9	$p < .10$	8.7	6.0
Personal remote memories	20.1	3.6	21.3	2.8	$p < .10$	21.5	2.5

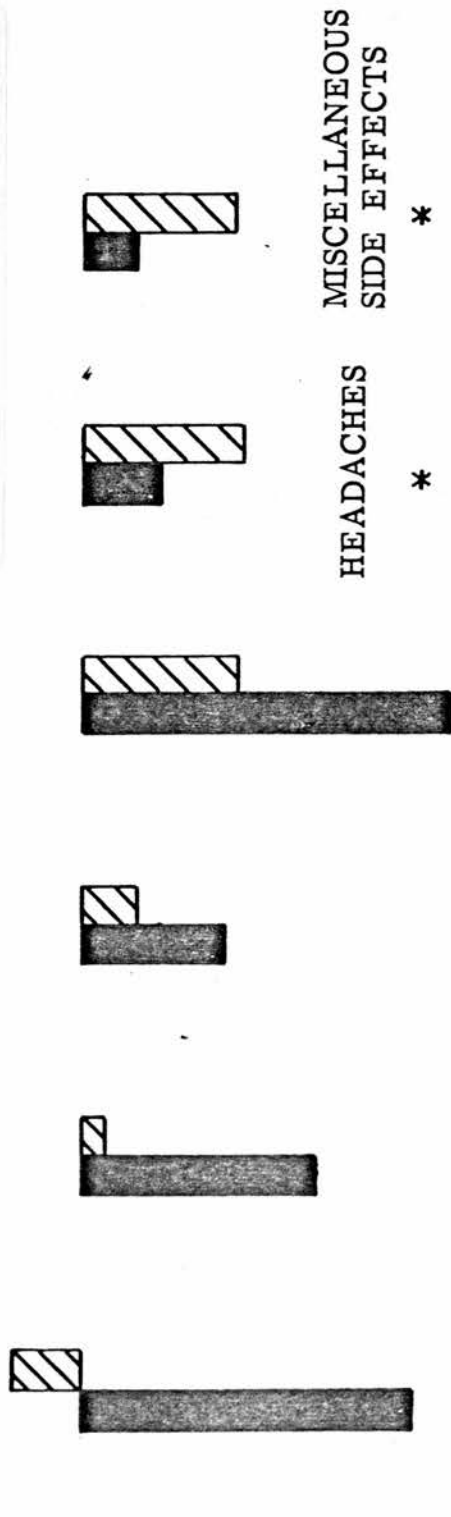
\*ECT group significantly less impaired. (On all other cognitive tests there were no significant differences.)

The trend toward a significant difference on the Personal Remote Memory Test should be qualified by pointing out that if one examines discrepancies between test occasions

FOUR MONTH FOLLOW-UP

\* P<.10  
\* \* \* P<.01

These bar graphs represent mean score differences from the normal population mean scores



PERSONALITIES 1970s \* \* \*  
PERSONAL REMOTE \*  
LITHIUM CARBONATE \*  
ANOMALOUS SENTENCES-ERRORS \*  
HEADACHES \*  
MISCELLANEOUS SIDE EFFECTS \*

Note. The significant advantage for the ECT group on the Mental Set Shifting Test, correct alternations measure, is not shown on this page.

SOLID BARS - ECT GROUP  
CROSS-HATCHED BARS - NON-ECT GROUP

rather than differences in total scores, a different picture emerges. On this test occasion, the ECT group remembered more previously forgotten memories (positive discrepancies) than did the non-ECT group. There were no significant differences between the patient groups and the non-patient group on how many previously remembered memories were forgotten (negative discrepancies). However, both patient groups remembered significantly more previously forgotten material than did the re-tested non-patient control group over an approximately comparable interval. (See Table 30.)

Table 30. Positive and negative discrepancies in personal remote memory.

Note. Positive discrepancy = previously forgotten item subsequently remembered.

Negative discrepancy = previously remembered item subsequently forgotten.

	<u>ECT group</u>		<u>Non-ECT group</u>		<u>Non-Patient group</u>	
	<u>mean</u>	<u>s.d.</u>	<u>mean</u>	<u>s.d.</u>	<u>mean</u>	<u>s.d.</u>
Positive discrepancies	2.6	1.9	1.8	1.7	1.2	1.2
Negative discrepancies	2.7	2.1	2.8	1.9	3.0	1.9

- 1.) ECT group vs non-ECT group  
 Positive discrepancies,  $t = 2.1$ ,  $p < .05$   
 Negative discrepancies, no significant differences
- 2.) ECT group vs non-patient group  
 Positive discrepancies,  $t = 4.4$ ,  $p < .001$   
 Negative discrepancies, no significant differences
- 3.) Non-ECT group vs non-patient group  
 Positive discrepancies,  $t = 2.0$ ,  $p < .05$   
 Negative discrepancies, no significant differences



There was a tendency for the ECT group to be on slightly more lithium ( $p < .10$ ) at this test occasion. At this time the ECT group complained of fewer side effects, particularly headache ( $p < .10$ ) and dizziness ( $p < .10$ ).

Relative to the normal control levels, the ECT group was significantly impaired on six other tests in addition to the three tests on which they were impaired relative to the non-ECT group. (See Table 31.)

Table 31. ECT group vs non-patient group at four months.

Test	Normal level		ECT group		Statistical significance
	Mean	s.d.	mean	s.d.	
Movement Time (milliseconds)	295	114	407	187	$p < .001$
Famous Personalities, 1960s	13.2	3.2	10.8	4.7	$p < .01$
Fluid Movement (seconds)	13.8	3.8	16.1	4.7	$p < .05$
Verbal Learning	26.0	7.0	32.1	14.6	$p < .05$
Mental set shifting, (errors)	3.2	2.6	5.2	5.2	$p < .05$
Decision Time (milliseconds)	387	128	470	249	$p < .05$

On this occasion the non-ECT group were somewhat less impaired relative to the normal control level than at the initial assessment. The three test scores that discriminated the non-ECT group and the normal group were the movement time ( $t = 2.6$ ,  $p < .05$ ) segment of the visual

choice reaction time apparatus, the mental set shifting test, error score, ( $t = 2.29$ ,  $p < .05$ ), and mental set shifting test, time score, ( $t = 2.23$ ,  $p < .05$ ). The non-ECT group remained less impaired than the ECT group but the difference was slight and not statistically significant. If the patient groups' performance levels relative to the normal level (as a percentage difference of the normal level) are averaged across all test scores, the ECT group performed 13.4% worse than the normal level and the non-ECT group 9.5% worse than the normal level.

Impaired Movement Time in the ECT group was correlated with depressive severity (Hamilton Rating Scale,  $r = +.36$ ,  $p < .05$ , Wakefield Self-Rating Scale,  $r = +.46$ ,  $p < .01$ ), depressive type (Newcastle Scale,  $r = +.34$ ,  $p < .05$ ), and the temporary use of major tranquillisers ( $r = +.39$ ,  $p < .01$ ) by a small number of patients. This latter variable also was related to impaired Fluid Movement ( $r = +.30$ ,  $p < .05$ ). Impaired Movement Time in the non-ECT group was correlated to the temporary use of major tranquillisers ( $r = +.34$ ,  $p < .05$ ) and the use of hypnotics ( $r = +.39$ ,  $p < .01$ ). There was also a non-significant trend at the 10% level of significance for Fluid Movement to be impaired in the non-ECT group. This was correlated with the temporary use of major tranquillisers ( $r = +.35$ ,  $p < .05$ ) and with the use of hypnotics ( $r = +.32$ ,  $p < .05$ ). Impaired Decision Time in the ECT group was correlated with number of previous depressive

episodes ( $r = + .30$ ,  $p < .05$ ). Impaired recognition of 1970s Famous Personalities by the ECT group was correlated with number of previous ECTs ( $r = - .35$ ,  $p < .05$ ), and was also correlated with hysterical personality (by Middlesex Hospital Questionnaire, ( $r = - .31$ ,  $p < .05$ ). However the use of hypnotics was correlated with better recognition of 1970s Famous Personalities ( $r = + .30$ ,  $p < .05$ ). Better recall of Personal Remote Memories was correlated with obsessionality (by Middlesex Hospital Questionnaire ( $r = + .36$ ,  $p < .05$ ), and with higher dosages of tricyclic antidepressants ( $r = + .30$ ,  $p < .05$ ).

ECT group and non-ECT group cognitive test comparisons at seven months.

At this stage, only one test differentiated the two patient groups at a statistically significant level. (See Table 32.).

Table 32. ECT group vs non-ECT group at seven months.

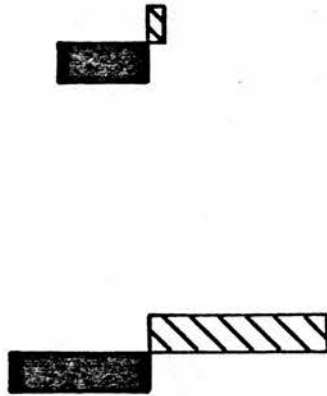
<u>Test</u>	<u>ECT group</u>		<u>Non-ECT group</u>		<u>Statistical significance</u>	<u>Normal Level</u>	
	Mean	s.d.	Mean	s.d.		Mean	s.d.
Logical Memory	14.3	4.6	12.2	3.4	$p < .05^*$	13.4	3.6

\*ECT group significantly less impaired. (On all other cognitive tests there were no significant differences.)

There was, however, a tendency for both patient groups to obtain slightly impaired scores on a small number of

SEVEN MONTH FOLLOW-UP

These bar graphs represent mean score differences from the normal population mean scores.



LOGICAL  
MEMORY

$P < .02$

VERBAL  
MEMORY

SEMANTIC  
FALSE HITS

$P < .10$

SOLID BARS - ECT GROUP  
CROSS-HATCHED BARS - NON-ECT GROUP

tests when compared with the normal controls. In other words, both patient groups were still performing less well than non-patients who were on no psychotropic medication and had few symptoms of depression. The ECT group, relative to the normal control group, was impaired on three tests (See Table 33).

Table 33. ECT group vs non-patient control group at seven months.

<u>Test</u>	<u>Normal Level</u>		<u>ECT group</u>		<u>Statistical significance</u>
	Mean	s.d.	Mean	s.d.	
Movement Time (milliseconds)	295	114	382	179	$p < .01$
Fluid Movement (seconds)	13.8	3.8	16.9	8.1	$p < .05$
Famous Personalities, 1960s	13.2	3.2	11.5	4.3	$p < .05$

Within the ECT group at this stage, impaired Movement Time was correlated with the temporary use of major tranquillisers ( $r = .50$ ,  $p < .001$ ); with type of depression (by Newcastle index,  $r = + .37$ ,  $p < .05$ ); and with depressive severity (by Hamilton Rating Scale,  $r = + .32$ ,  $p < .05$ ). Impaired Fluid Movement was correlated with the chronic use of minor tranquillisers ( $r = + .37$ ,  $p < .05$ ) and with tricyclic antidepressants ( $r = + .33$ ,  $p < .05$ ). Impaired recognition of 1960s Famous Personalities was correlated with depressive severity (by Hamilton Rating Scale,  $r = - .32$ ,  $p < .05$ ),

and with the use of minor tranquillisers ( $r = - .35$ ,  $p < .05$ ).

The non-ECT group, relative to the normal control group, was significantly impaired on three tests. There were also non-significant trends toward impairment on two other tests. (See Table 34.).

Table 34. Non-ECT vs non-patient control group at seven months.

<u>Test</u>	<u>Normal Level</u>		<u>Non-ECT group</u>		<u>Statistical significance</u>
	Mean	s.d.	Mean	s.d.	
Movement Time (milliseconds)	295	114	364	135	$p < .01$
Personal Remote Memory	21.5	2.5	20.2	2.8	$p < .05$
Sentence Repetition	8.7	6.0	12.0	7.8	$p < .05$
Fluid Movement (seconds)	13.8	3.8	16.6	9.4	$p < .10$
Logical Memory	13.4	3.6	12.2	3.4	$p < .10$

Within the non-ECT group at this stage, impaired recall of Personal Remote Memories was correlated with depressive severity (by Hamilton Rating Scale,  $r = - .30$ ,  $p < .05$ ). The impairments on Movement Time and the Sentence Repetition Test were not related with psychiatric symptoms, psychotropic medication, previous ECTs or type of depression. The tendency toward slower performance on the



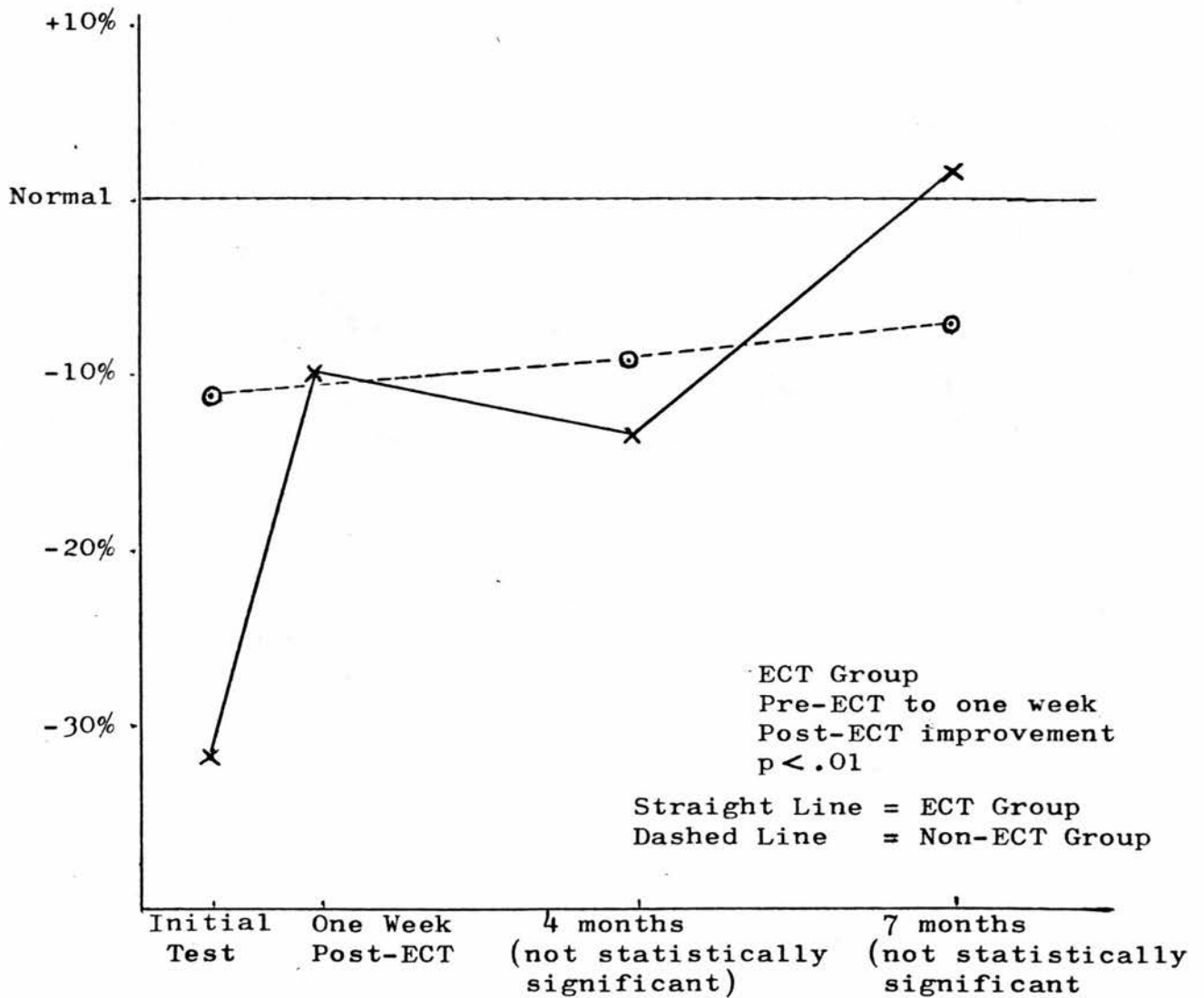
Fluid Movement Test was correlated with lithium treatment ( $r = + .41$ ,  $p < .01$ ) and with the temporary use of major tranquillisers ( $r = + .29$ ,  $p < .05$ ). The tendency toward poor immediate recall on the Logical Memory Test was correlated with depressive severity (by Wakefield Self-Rating Scale,  $r = - .33$ ,  $p < .05$ ; by Hamilton Rating Scale,  $r = - .30$ ,  $p < .05$ ).

Thus, at the final follow-up, both patient groups' cognitive functioning was very similar, with a slight advantage in favour of the ECT group. Both patient groups were also modestly impaired on a minority of tests when compared to the normal control levels. The ECT group and non-ECT group were 29% and 23% slower respectively on the Movement Time measure than the normal control group; also, the patient groups were 22% and 20% slower respectively on the Fluid Movement measure than the normal control group. The ECT group's recognition of 1960s Famous Personalities was 13% poorer than the normal control levels. At this occasion, the non-ECT group made 38% more errors on Sentence Repetition, recalled 9% less of the Logical Memory paragraph, and recalled 6% less of their Personal Remote Memories than did the non-patient controls. For both patient groups, if their performance levels relative to the normal level were averaged across all test scores (as a percentage difference of the normal level), the ECT group performed 1.5% better than the normal level, and the non-ECT group performed 8.1% below



the normal level. If the normal range of cognitive functioning is stringently defined as  $\pm 0.5$  standard deviation from the mean normal performance level, then both patient groups' cognitive functioning can be seen to be well within the normal range at this last follow-up.

Figure 1. Comparison between ECT group and non-ECT group relative to the non-patient control group; all test score decrements averaged.



$p < .01$

C) Comparison between unilateral and bilateral ECT

It was found that unilateral ECT was equivalent to bilateral ECT in relieving depressive symptoms at one week, four months and seven months follow-up testings. (See Table 35.)

Table 35. Ratings of depressive severity at each test occasion, bilateral ECT group compared to unilateral ECT.

Group	Pre-ECT		1 week		4 months		7 months	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
<u>Bilateral</u>								
Hamilton	26.4	7.6	9.7	6.6	9.5	7.6	10.7	8.8
Wakefield	25.6	5.3	13.2	6.9	13.0	6.9	13.3	9.5
<u>Unilateral</u>								
Hamilton	27.6	8.3	13.5	10.2	13.3	9.5	11.5	9.8
Wakefield	23.9	8.0	16.0	9.9	13.0	10.8	14.1	10.9

There were no statistically significant differences between the patient groups on level of depression at any of the testing occasions, nor between the groups on the amount of clinical change effected by either treatment.

Neither the bilateral ECT group nor the unilateral ECT group required more psychotropic medication than the

other group before or after ECT, although there was a nonsignificant trend ( $p < .10$ ) for more patients in the bilateral ECT group to be started on lithium between the immediate post-ECT testing and the four-month followup. Lithium levels were not significantly correlated with any improvement or dysfunction on any cognitive test, with the possible exception of Visual Design Learning ( $p = .01$ ). Further multiple analyses of variance, with lithium levels as a covariate, revealed that the difference in lithium levels did not differentially effect any of the cognitive test results of either ECT group on any test occasion.

Clinical improvement was obtained with an equivalent number of treatments per patient, ie.,  $7.3 (\pm 0.6)$  for the bilateral ECT group and  $7.3 (\pm 0.5)$  for the unilateral ECT group.

However, when the results of the cognitive tests were compared, the unilateral ECT group were significantly less impaired at the one week post-ECT testing. (See Table 36.).

Table 36./

Table 36. Comparison between cognitive test scores of bilateral and unilateral ECT groups, one week post-ECT.

Test	Bilateral ECT group		Unilateral ECT group		Significance (by Dependent t, 2 tailed, df 14)
	Mean	s.d.	Mean	s.d.	
Verbal memory, structural false positives (change)	+0.60	.74	-0.73	.41	$p < .01$
Visual design learning	31.5	12.0	23.5	9.6	$p < .05$
Delayed recall	3.9	2.0	5.5	1.7	$p < .05$
Verbal learning	35.7	16.7	28.4	10	$p < .10$

In fact, the unilateral ECT group were scoring close to, or better than, the normal control levels on 19 out of the 24 cognitive tests within one week after treatment, whereas the matched bilateral ECT group only approached the normal values on 15 out of 24 tests. The severity of the bilateral ECT group's decrements relative to the normal levels were also somewhat greater than the unilateral ECT group's levels.

Prior to treatment, the bilateral ECT group's average cognitive impairment was 14.5% below normal levels and the unilateral ECT group's average cognitive impairment was 34.5% below normal levels. One week after treatment the bilateral ECT group's average cognitive impairment was 15.5% below normal levels and the unilateral ECT group was at the average normal level. (See Figure 2.)

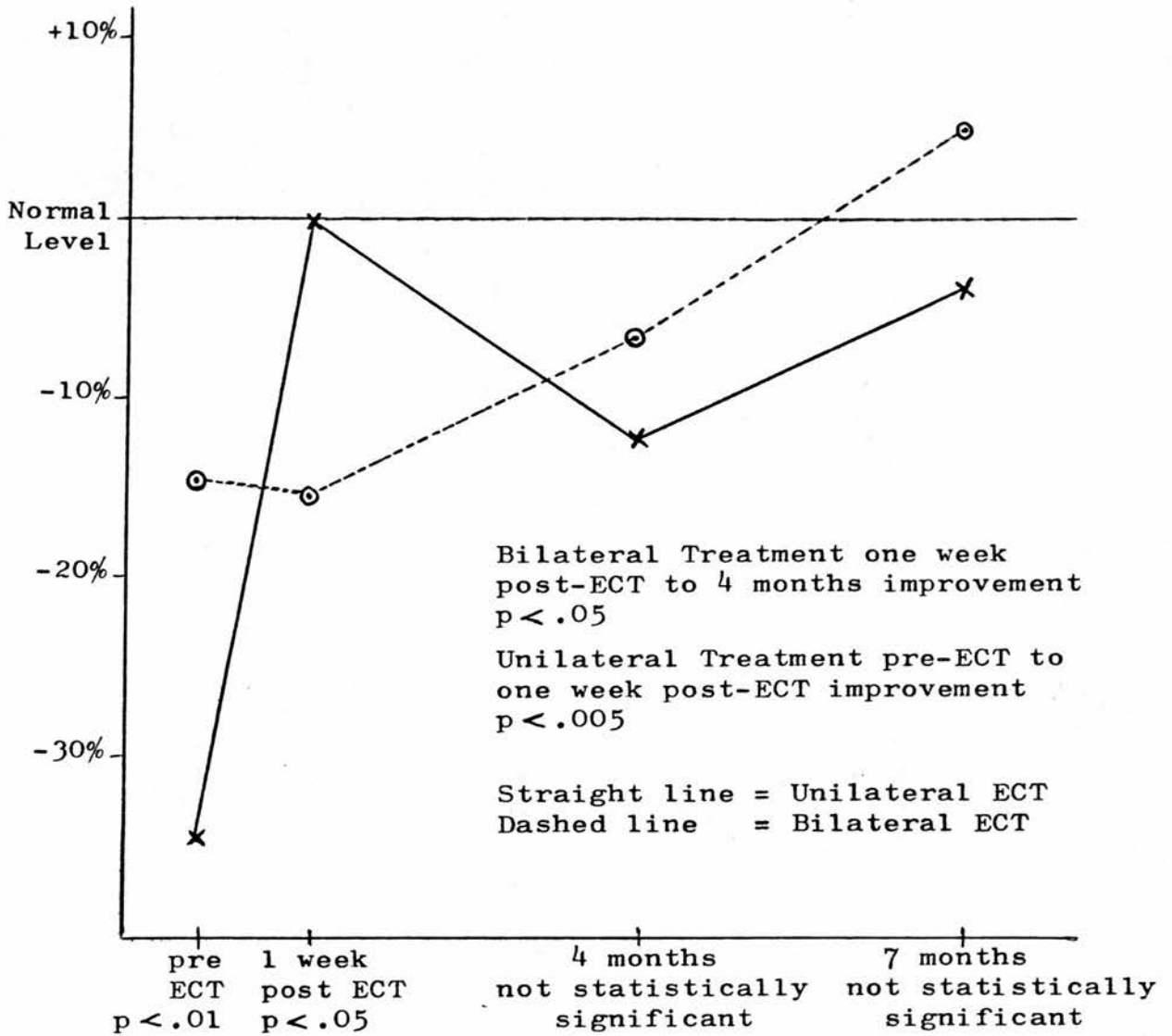


Figure 2. Comparison between the bilateral ECT group and the matched unilateral ECT group; all test score decrements averaged.

By the four-month followup, the bilateral ECT group had made substantial gains on a number of cognitive tests. (See Table 37.) There were no cognitive test score differences between the bilateral ECT group and the unilateral ECT group which approached statistical significance.

Table 37. Significant cognitive test score improvements of bilateral ECT group between one week and four months.

Test	<u>1 week</u>		<u>4 months</u>		<u>Normal Level</u>		<u>*Dependent t</u>	<u>Significance (2-tailed)</u>
	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>		
Delayed Recognition	7.8	1.0	8.5	0.7	8.5	0.9	3.56	p = .004
Logical Memory	11.7	4.2	15.3	4.2	13.4	3.6	2.82	p = .014
Famous Personalities, 1930s	5.9	5.1	7.7	5.6	7.4	4.4	2.81	p = .014
Delayed Recall	3.9	2.1	4.8	1.4	5.5	1.6	2.61	p = .021
Incidental Visual Memory	10.8	2.3	11.9	2.1	11.3	2.1	1.77	p < .10
-----								
Subjective Rating of Memory	2.5	0.8	1.6	1.0	1.5	0.7	3.39	p = .005
	Moderate to severe impairment		Mild to moderate impairment		Mild to moderate impairment			
Unilateral ECT Level	1.6	1.2	1.5	1.0				
	Mild to moderate impairment		Mild to moderate impairment					

\*Dependent t is between bilateral ECT group at 1 week and at 4 months.

The substantial gains made by the bilateral ECT group between one week and four months were not paralleled by similar improvements in the unilateral ECT group. This was because the unilateral ECT group had made larger gains within the first week following treatment. No single test score of the unilateral ECT group diverged from the normal level to a statistically significant degree at four months. At the four-month followup, the bilateral ECT group were significantly below the non-patient group on four tests: Famous Personalities, 1960s ( $t = 2.87$ ,  $df\ 64$ ,  $p < .01$ ), Decision Time ( $t = 2.23$ ,  $df\ 64$ ,  $p < .05$ ), Movement Time ( $t = 2.83$ ,  $df\ 64$ ,  $p < .01$ ) and Fluid Movement Time ( $t = 3.24$ ,  $df\ 64$ ,  $p < .01$ ). If both ECT groups' performance levels relative to the normal level (as a percentage difference from the normal level) are expressed as an average of the test scores, the bilateral ECT group was 6.8% below normal levels and the unilateral ECT group 12.2% below normal levels. (See Figure 2.)

At the seven-month followup, the lack of any significant difference between the bilateral ECT group and the unilateral ECT group on the cognitive tests was repeated. The unilateral ECT group obtained normal test results, with the exception of Movement Time, which showed a slight trend ( $t = 1.7$ ,  $df\ 64$ ,  $p < .10$ ) toward impairment relative to the non-patient controls. The bilateral ECT group improved (dependent  $t = 1.98$ ,  $df\ 14$ ,  $p = .07$ ) on Famous



Personalities, 1960s, bringing them into the normal range on this test. However, the bilateral ECT group remained below the non-patient group on Movement Time ( $t = 2.91$ ,  $df\ 64$ ,  $p < .01$ ) and Fluid Movement Time ( $t = 2.81$ ,  $df\ 64$ ,  $p < .01$ ).

At this final followup, the bilateral ECT group was on average 4.9% superior to the normal cognitive test levels, and the unilateral ECT group was on average 4% below the normal levels. (See Figure 2.)

D) Relationships between subjective cognitive complaints, objective tests, psychopathology, and other variables.

The younger patients in both treatment groups tended to have more specific cognitive complaints, as measured by the Cognitive Failures Questionnaire (CFQ), both before and after treatment. (See Table 38.) This was not the case for volunteer subjects. A study in Edinburgh by Graham-White, Weeks, and Wilkinson (in preparation) revealed a nonsignificant correlation of  $-.06$  between CFQ and age ( $n=570$ ).

Table 38. Correlations between age and CFQ, both patient groups.

	Pre-treatment	4 months	7 months
ECT group	$-.29$ , $p < .05$	$-.20$ , n.s.	$-.34$ , $p < .05$
Non-ECT group	$-.48$ , $p < .001$	$-.33$ , $p < .05$	$-.32$ , $p < .05$

Patients within the non-ECT group who had received more previous ECTs had fewer cognitive complaints, the correlations between the CFQ and numbers of previous ECTs being - .39 ( $p < .01$ ) at initial testing, - .36 ( $p < .05$ ) at four months, and - .32 ( $p < .05$ ) at seven months. This relationship did not exist within the ECT group.

The ECT group's initial estimation of dysfunction was significantly related to objectively determined dysfunction on 7 out of 24 test scores. (Due to the relative youth of those complaining, the two correlations with Famous Personalities of earlier decades were probably artefactual.) By comparison, there were only two significant correlations between the CFQ and objective tests within the non-ECT at the initial testing, and these were in the opposite direction, ie., both indicating an association between more complaints and less disturbed visual learning and memory. (See Table 39.)

Table 39. Correlations between the Cognitive Failures Questionnaire (CFQ) and objective tests, initial testing.

<u>ECT group</u>		<u>Non-ECT group</u>	
<u>Test</u>	<u>Correlation</u>	<u>Test</u>	<u>Correlation</u>
Decision Time	+ .48 ***	Incidental	+ .36 **
Movement Time	+ .45 ***	Visual Memory	
Famous Personalities, 1930s	- .39 **	Visual Design	- .31 *
Famous Personalities, 1940s	- .37 **	Learning	
Personal Remote Memory	- .35 *		
Delayed Recall	- .33 *		
Cube Analysis, errors	+ .30 *		

\*\*\*  $p < .001$

\*\*  $p < .01$

\*  $p < .05$

At the four-month followup, the only significant relationship within the ECT group between subjective reports and objective tests indicated that only modest degrees of psychomotor slowing were related to increased complaints (Movement Time and CFQ,  $r = + .34$ ,  $p < .05$ ; Decision Time and CFQ,  $r = + .31$ ,  $p < .05$ ). At the seven-month followup, there were no relationships at all between the CFQ and objective tests within the ECT group.

The non-ECT group continued to show nonsignificant or paradoxical correlations between the CFQ and objective tests. At four months, the only significant correlations were between more complaints and more accurate perceptual aptitude (CFQ and Cube Analysis, errors,  $r = - .29$ ,  $p < .05$ ), and between more complaints and more efficient verbal memory (CFQ and Verbal Memory, sensitivity,  $r = + .30$ ,  $p < .05$ ). At seven months, the only significant correlations were between more complaints and a less strict verbal memory strategy (CFQ and Verbal Memory, response bias,  $r = - .43$ ,  $p < .01$ ), between more complaints and faster psychomotor speeds (CFQ and Fluid Movement,  $r = - .31$ ,  $p < .05$ ), and between more complaints and better visual memory (CFQ and Incidental Visual Memory,  $r = + .29$ ,  $p < .05$ ).

There were no significant correlations at all within the non-patient control group between subjective cognitive complaints and any of the objective tests; the average

correlation between the CFQ and the objective tests was + .007.

There were, however, significant correlations between cognitive complaints and various measurements of depressive severity and neurotic symptoms within both patient groups at all test occasions. (See Table 40.). The correlations, for instance, between the CFQ and Wakefield Scale at four months are practically as high as the test-retest reliability of the Wakefield Scale itself.

Table 40. Correlations between the Cognitive Failures Questionnaire (CFQ), the Hamilton Rating Scale (HRS), Wakefield Self-Rating Scale, and Middlesex Hospital Questionnaire (MHQ) subscales; both patient groups.

Scale	<u>Initial Test</u>		<u>4 Months</u>		<u>7 Months</u>	
	ECT group	Non-ECT group	ECT group	Non-ECT group	ECT group	Non-ECT group
HRS	+.33*	+.29*	+.48***	+.44**	+.57***	+.32*
Wakefield	+.40**	+.40**	+.62***	+.64***	+.55***	+.51***
MHQ anxiety	+.46***	+.56***				
MHQ fear	+.48***	+.23 n.s.				
MHQ somatic complaints	+.45***	+.47 ***				
MHQ depression	+.40**	+.66***				

\*\*\*  $p < .001$  \*\*  $p < .01$  \*  $p < .05$

The significant correlations between cognitive complaints and neurotic symptoms were also replicated across two large samples of non-patient volunteer subjects. (See Table 41.)

Table 41. Correlations between the CFQ and the MHQ subscales; non-patient volunteer subjects.

MHQ subscale	Group I (n=164)	Group II (n=575)
Anxiety	+ .42	+ .40
Fear	+ .42	+ .28
Obsessions	+ .19	+ .13
Somatic Complaints	+ .30	+ .30
Depression	+ .47	+ .43
MHQ Total	+ .42	+ .41

All correlations were significant at  $p < .001$ , except Obsessions (Group I) which was  $p < .05$ . Group I was tested by the author. Group II was studied by Graham-White, Weeks, and Wilkinson (in preparation).

Table 42. Summary of impaired and improved cognitive test results, significant correlations with other variables, both patient groups at both long-term followups.

ECT Group				
Four months		Seven months		
Test	Correlate	r	Test	Correlate
Movement Time, Impaired	Hamilton	+.36*	Movement Time, Impaired	Phenothiazines
	Wakefield	+.46**		Newcastle
	Newcastle	+.34*		Hamilton
	Phenothiazines	+.39**		
Fluid Movement, Impaired	Phenothiazines	+.39**	Fluid Movement, Impaired	Benzodiazepines
Decision Time, Impaired	Previous No. of Depressive Episodes	+.30*	Tricyclics	
Famous Personalities, 1970s, Impaired	Previous No. of ECTs	-.35*	Famous Personalities, 1960s, Impaired	Hamilton
	Hysterical Personality, MHQ	-.31*	Benzodiazepines	
Famous Personalities, 1970s, Improved	Hypnotics	+.30*		
Personal Remote Memory, Improved	Obsessional Traits	+.36*		
	Tricyclics	+.30*		

\*\*\* p < .001    \*\* p < .01    \* p < .05

(Continued)

Table 42. (Continued)

<u>Four months</u>		<u>Seven months</u>		<u>Non-ECT Group</u>	
<u>Test</u>	<u>Correlate</u>	<u>r</u>	<u>Test</u>	<u>Correlate</u>	<u>r</u>
Movement Time, Impaired	Phenothiazines Hypnotics	+ .34* + .39**	Personal Remote Memory, Impaired	Hamilton	-.30*
Fluid Movement, Impaired	Phenothiazines Hypnotics	+ .35* + .32*	Fluid Movement, Impaired	Lithium Phenothiazines	+ .41** + .29*
			Logical Memory, Impaired	Hamilton Wakefield	-.30* -.33*

\*\*\*  $p < .001$       \*\*  $p < .01$       \*  $p < .05$



Table 43. Factor Scores of both patient groups, the normal control group, and the cerebral dysfunction group.

Factor	Normal Control Group		ECT Group		One Week	4 months	7 months
	Initial	5 months	Initial				
I Learning	-.35	-.44	-1.03		-.54	-.49	-.38
II Speed	-.44	-.55	-3.87		-1.69	-1.57	-1.15
III Retrieval	-.44	-.55	-1.06		-1.11	-.73	-.52
IV Remote Memory	-.15	-.19	-.78		-.80	-.66	-.40

Factor	Cerebral Dysfunction Group		Non-ECT Group		4 months	7 months
	Initial		Initial			
I Learning	-1.99		-.77		-.42	-.49
II Speed	-5.55		-2.01		-1.13	-1.18
III Retrieval	-1.69		-.65		-.41	-.72
IV Remote Memory	-1.28		-.27		-.21	-.35

This table shows the factor scores of the ECT group and non-ECT group at each test session. The only significant differences between these two groups were at the initial testing, for the Speed, Retrieval and Remote Memory factors. Normal control levels and the levels of the brain-damaged patient group are included for comparison.

Discussion

This study supports the view that ECT, when used in everyday clinical circumstances to treat depressed patients, does not cause lasting cognitive impairment. Before this principle finding can be accepted, the research design should be examined to determine whether methodological defects have influenced this conclusion. The present design can be systematically evaluated by relating it to twelve factors that are potential sources of design invalidity. (Campbell and Stanley, 1963.)

Eight of these factors concern internal validity; these variables, if not controlled in the design, might produce effects confounded with that of the experimental stimulus. The first factor, termed history, refers to the specific events occurring between measurements in addition to the experimental stimulus. There were no significant differences between the two patient groups on this factor. Differences in psychotropic medication, had they existed, could have been classified as this type of extraneous variable. The ECT group were administered somewhat more lithium between their immediate post-ECT testing and three months later. However, previous research (refer to Chapter 3. of Literature Review) and the present data, both indicate that this difference would have had, and did have, negligible effect on the cognitive test results. No other relevant event or variable of the many that were monitored happened to one group more often than the other

group between the test occasions; therefore, no plausible rival hypothesis to account for the main finding can be mounted on the basis of the history variable.

The second factor, maturation, refers to processes within the subjects that operate as a function of the passage of time per se. This was controlled for by the design by concurrently re-testing two similar patient groups at equivalent intervals.

The third factor, testing, applies to the effects of taking a test upon the scores of subsequent repeated testings. This was partly controlled by the multiple group design, partly by the use of parallel tests, and partly by counterbalancing the order of test presentation. Also, the patient groups' improvement towards the normal level cannot be attributed to practice; the re-tested non-patient group demonstrated a negligible tendency in the opposite direction. Squire, Slater, and Miller (1981) have also concluded that repeated testing, even with identical test forms, exerts a negligible effect in this type of study.

The fourth factor, "instrument decay", refers to autonomous changes in the calibration of the measuring instruments that could produce changes in the obtained measurements. Inherent in the concept of psychometric stability is the idea that such changes internal to tests are minimized. As

can be seen in the Normative Studies section, most of the tests used in this study are sufficiently stable. The electronic timers and stopwatch, which did require periodic calibration, were very accurately adjusted.

The fifth factor, termed statistical regression, is not applicable to the present design. It is only relevant to designs in which all subjects are selected because of their extremity on a selected variable.

The sixth factor concerns biases resulting from differential selection of respondents for the comparison groups. Randomization is the usual procedure for achieving pretreatment equality of groups. Without randomization, initial group differences could well have come about through the differential recruitment of individuals composing the groups. Matching on background characteristics can sometimes be an ineffective alternative, particularly in those instances in which the persons in one treatment group have sought out exposure to a specific treatment; this was not the case in the present study.

Patients were not randomly allocated to treatment. To do so could have been assailed as unethical. (Pryce, 1978; Swazey, 1978; Walters, 1977; Alexander, 1978; Helmchen and Müller, 1975; Davidson, 1969; Rutstein, 1969). Random allocation does not guarantee equivalence of

treatment groups. Had random allocation been required, subjects would have had only a 50% chance of receiving ECT. Selective referral would probably have restricted both samples in size and depressive severity, thus restricting the generalizability of the results. Random allocation to ECT and simulated ECT would have had the advantage that testing could have been conducted blindly throughout the study, but the disadvantage that any cognitive impairment due to repeated anaesthesia or to hypoxia could not have been assessed as this would have been controlled for in the design.

Although the design used in this study is weaker than a true randomized groups design, it is able to provide information which can legitimately exclude the hypothesis that ECT does have certain effects, i.e., specific forms of cognitive impairment. Data from the comparison groups can rightly help to determine the correct interpretation.

Without random allocation, the patients in the ECT and non-ECT groups were in fact very similar on those variables thought to exert an effect on cognitive function, e.g., age, social class, educational level, intelligence, depth of depression, etc. The patient groups were different on two variables, the endogenous-neurotic continuum and the number of prior ECTs. These variables themselves are related to the type of treatments that are prescribed for depressed patients. ECT is viewed as particularly

efficacious in the treatment of endogenous depression. Good response to ECT in a previous depressive episode provides a rationale for administering ECT again for a subsequent depressive illness. However, these two differences could not lead to the erroneous acceptance of the null hypothesis.

The ECT group was rated as more endogenous in their index episode than was the non-ECT group, and endogenous depression has been shown to be more detrimental to cognitive function than neurotic depression. (See Chapter 1. of Literature Review.) It would be wrong on empirical grounds to suppose that because the ECT group contained more patients with more endogenous features, this variable would bestow any relative advantage upon this group, either initially or at follow-up. The same applies to differences in the number of previous ECTs. If these differences had effected this study's findings, they most probably would have lead to the (incorrect) interpretation that ECT does cause cognitive impairment, but not that ECT does not cause such impairment. .

The seventh factor, differential loss of subjects from the comparison groups, did not confound the main finding insofar as the control variables and other inter-group characteristics remained unaffected by patient drop-out. Research drop-outs were quantitatively and qualitatively similar across both patient groups. There remains the

possibility of complex interactions which would tend to make the nature of the drop-outs different between the two patient groups. As far as can be determined from post-hoc analyses of all the data obtained about the drop-outs, this was not the case.

The eighth factor, selection-maturation interaction, is in general uncommon. In this study, the single known variable which could have been both selection-specific and interactive with maturation was the endogenous-neurotic variable. However, repeated re-testing provided three consecutive disconfirmations of cognitive dysfunction after ECT. Because of this, because maturation was controlled, and because change due to re-testing alone was minute, this interaction does not represent a plausible source of erroneous inference.

The last four factors presented by Campbell and Stanley (1963) are those which could jeopardize the external validity or representativeness of a research design.

The first generalizability factor, the reactive effect of testing, is that effect which pre-treatment testing may have on the subjects' sensitivity to the experimental variable. If this were a serious concern, it could make the results obtained from a pretested sample unrepresentative of the effects of ECT for the unpretested population from which the sample was drawn. This is an



unlikely effect in this type of study, as the tests and treatments were in different modes, the former primarily functional and the latter primarily biological. Also, the tests focussed on cognition, and the treatments pertained primarily to the alleviation of affective disorder.

Furthermore, studies in which there were no pretests (e.g., Squire and Chace, 1975) or fewer pretests (e.g., Johnstone et al, 1980) have arrived at similar conclusions to studies with comprehensive pretests.

The second generalizability factor is the possible interaction effect of selection biases and the experimental variable, and overlaps with the sixth internal validity factor. The small long-term effect of ECT on cognitive function as demonstrated could possibly pertain only to that unique population from which the patient groups were selected, i.e., depressed inpatients who fulfil the research criteria, who also volunteer for repeated memory tests and additional psychiatric interviews. Generally speaking, the more cooperation solicited, the more disruption of routine, and the higher the refusal rate, the more chance there is for this selection-specificity effect. The initial joint psychiatric-psychological assessment required ninety minutes, about 1% of each patient's pre-treatment time in hospital. The refusal rate, at less than 14% overall, was reasonably small; patients who refused were equally likely to be treated with ECT as not. Therefore, the patients in this realistic

study can be regarded as broadly and genuinely representative of patients with serious depressions. Because random allocation to treatment was not required, patients in this study were probably more typical of patients treated with ECT than those in random allocation studies. (e.g., Johnstone et al, 1980.) In such studies, clinicians may have been reluctant to refer patients unselectively, for instance, routing very endogenous cases, suicidal cases, or treatment-resistant, chronic cases to other units.

The third generalizability factor is concerned with the reactive effects of the experimental arrangements. This was minimized by the use of existing modes of treatment delivery. In this respect, the naturalistic properties of this design were advantageous. Repeated testing itself could be viewed as reactive; however, in a repeated follow-up design of this nature, the latter follow-ups could be viewed as being of more importance than the pre-treatment test. It is at the latter follow-ups however that testing becomes less reactive, due to subject acclimatization and the repetitive nature of the re-tests.

The fourth generalizability factor concerns multiple-treatment interference. It is likely to occur whenever multiple treatments are applied to the same subjects, as the effects of prior treatments are never believed to be

wholly erased. However, this factor was controlled by the ECT-plus-medication vs non-ECT medication group comparison. It is also believed that antidepressant medication effects on the central nervous system are most probably limited to the period of administration and several weeks thereafter. (C.P.L. Freeman, personal communication.) Furthermore, the prophylactic drug treatment of the ECT group is by no means atypical, and is often recommended.

In summary, none of the factors that could jeopardize the validity of a research design were sufficiently compelling to undermine confidence in this research study's central finding, to wit, ECT does not cause lasting impairment.

None of the very wide ranging battery of sensitive tests used to examine all relevant areas of cognitive function showed lasting impairment in the ECT group. The test battery used was more comprehensive than that in any other similar study to date. Memory functions tested included free recall, relearning rate, and recognition, both in the auditory-verbal and visual-spatial modalities. Tests of both immediate and delayed retrieval were used. Both short-term and long-term memory were assessed. Long-term memory was tested for both personal and impersonal facts. The personal remote memory test was individually constructed for each patient, and extended from early childhood to the day of testing. The impersonal remote

memory test covered the last 50 years; in the case of the oldest patients from age 20 onwards, and for the youngest patients from the earliest point in which their long-term memory could record and hold information.

A number of related areas were also tested, such as perceptual aptitude, concentration, short-term predictive planning (in both the auditory-verbal and visual-spatial modalities), internal information processing speed, discrete peripheral movement speed, fluid repetitive movement speed, verbal fluency, speech comprehension, processing and expression, vocabulary and non-verbal problem-solving. Again, there were no enduring deficits specific to patients treated with ECT on any of these cognitive functions.

It is clear that moderately severe depression, particularly of the psychotic/endogenous variety, can profoundly impair cognitive function. This research accords well with the previous documented evidence of a relationship between depression and cognitive dysfunction. The ECT group, while being depressed to an equivalent degree of severity to the non-ECT group, contained more endogenous cases. Therefore the study began with the ECT group at a distinct disadvantage compared to the non-ECT group and the non-patient control group on many standard psychometric tests.

One indication of this difference was that prior to treatment five of the 51 ECT patients demonstrated quite appalling forgetfulness. This was reflected in multiple

observations of their ward behaviour, to the extent that experienced clinical staff entertained serious suspicions that these patients might have been suffering from early dementia.

Most of the patients in this study reported, on close questioning, that their cognitive abnormalities, particularly poor concentration, had slightly preceded their depressive symptoms. The onset of these cognitive abnormalities was often insidious, and in some instances the patient had endured them for quite long periods. Indeed, some patients claimed to have attempted to accommodate or adjust to the early difficulties, such as those in recalling the names of acquaintances, but inevitably they were unsuccessful. Many feared that these difficulties indicated a more malignant disorder; reassurance to the contrary also failed, apparently because of their learning difficulties and refractory pessimism.

The patients in this study fell into the moderate to severely depressed category, with a mean Hamilton score of 26.5 (undoubled). As compared to the majority of similar modern studies, the patients in this study were more severely depressed. From those studies in which depressive severity and duration of depression can be ascertained from an objective evaluation, three studies (Cronholm & Molander, 1964; Laurell, 1970; Hesse et al,

1978) were based upon patients with mild illnesses; four other studies (Hemsi et al, 1968; Zung, Rogers and Krugman, 1968; Turek and Block, 1974; Johnstone et al, 1980) were based on moderately ill patients. Only the study by Halliday et al (1968) contained patients who were as severely ill as those in this study; however, these investigators restricted their study to patients whose index depressive episode was less than one year in duration.

These significant differences in depressive severity and chronicity may partly explain the remarkable improvements on a third of the cognitive test scores by the ECT group at the one week post-treatment assessment. It could be argued that the bias in previous studies toward patients with milder disorders resulted in these patients demonstrating a proportionately milder cognitive disturbance prior to ECT. They therefore had less scope for improvement on those types of tests which would have been beneficially affected by the alleviation of (severe) depressive symptoms. Alternately, patients with milder depressions, or with less of an endogenous component to their depressions, could be more likely to have relatively more ECT-related cognitive disturbance soon after treatment. These latter factors would be difficult to disentangle, and retrospective analyses of previous studies are not possible. None of the papers alluded to in the preceding paragraphs, for instance, provide any



quantitative data on the endogenous/neurotic dimension. This variable may prove to be more relevant to cognitive functioning than it has been to the classification and treatment of depressions.

In this study, the two largest improvements one week after ECT were related to psychomotor activity. These were the improvements on Decision Time and Movement Time, which were as likely to occur whether bilateral or unilateral treatment was administered. The other large improvement, that for Visual Design Learning, seemed to be somewhat accelerated by unilateral treatment. The smaller reductions in semantic false positive errors in verbal memory and errors in sentence repetition were probably a secondary effect of an improvement in verbal acquisition learning, as reflected in the auditory-verbal learning test. This improvement in turn was common to both bilateral and unilateral treatment, but the latter was associated with more improvement. The other two improved test results one week after ECT, those for Cube Analysis and Positional Learning, shared at least three common features. They required visual perceptiveness, errors on them at the initial testing were significantly correlated with more signs and symptoms of endogenous depression, and the ECT group's mean scores on these tests even then were within normal limits.

Of the seven cognitive tests that showed significant



improvement, initial deficits on three tests were associated with illness severity; however, these three deficient tests and two more tests which showed immediate improvement were correlated with the endogenous depression diagnosis variable. This amounts to weak indirect evidence that although ECT certainly does decrease depressive severity, its therapeutic mode of action is slightly more related to its anti-endogenous or anti-psychotic properties.

If a course of ECT is related to damage to the brain, as measured by functional assessment, those who received more treatment would be more likely to have poorer test results. Such deficits theoretically would be more readily detected shortly after the last treatment. That there was no relationship whatever between number of treatments and objective test deficits therefore is another piece of evidence to suggest that ECT does not cause damage to the brain. Similar evidence in line with this argument is that there were also no greater (cumulative) impairments amongst those patients who formerly received multiple courses of treatment. There was clearly no sensitization effect; those who received many treatments in their past psychiatric histories often recovered their cognitive function as much and as well as those who underwent ECT for the first time.

The ECT group's cognitive function, as measured by specific

test comparisons with the non-ECT group and the non-patient group, continued to show more sustained improvement at three months after treatment. The single statistically significant difference indicated that the ECT group was experiencing mild difficulties in recognising the names of recent famous personalities, or in accessing such information, which would still be in their long-term memory store. That there was a minor degree of difficulty with the long-term memory store is further corroborated by a non-significant trend in the same direction on the Personal Remote Memory test. But it is important to emphasise that these differences were small; they do not represent further decline from the pre-ECT assessment, but stayed at the same level while the general trend was towards improvement.

That impersonal remote memory was somewhat more impaired than personal remote memory was fairly predictable from what is already known about memory processes. Memories of events which have personal relevance and have been actually experienced by an individual would be expected to better resist the effects of depression and treatment.

An indeterminate fraction of these slight impairments could sensibly be viewed as due to the retrograde amnesic effects of ECT. This retrograde amnesia would theoretically effect those memories that are most susceptible - those not originally learned at all, but merely passively

noticed in the course of everyday life, and those so noticed in that period of time during which the patient's depression was developing and beginning to "build up" and unfold. Thus vulnerable memories in vulnerable persons are temporarily denied an easy and automatic retrieval in the recovery phase soon after a major depression. It is not known whether these weak memories were still in the long-term memory store but unable to be rendered manifest quickly in a test situation, or were erased without trace. The results at the final retest six months after treatment favour the former alternative, as does the analysis of positive and negative discrepancies in personal remote memory. ECT was associated, on the basis of this analysis, with as much remembering as forgetting. Furthermore, the rate and amount of forgetting within the ECT group at follow-up is within normal limits as established by direct comparison with a sample of ordinary people retested over a comparable interval.

While not trying to diminish the fact of a statistically significant difference, the meaning of the numerical difference in the Famous Personalities (1970's) scale in actual terms is small. It represents either one famous name out of ten not being recognised, or two famous names being vaguely recognised instead of confidently recognised.

Tests of remote memory at three months after ECT were slightly more sensitive to extraneous factors within the

ECT group. Patients with hysterical (extravert) personality features did somewhat less well on the Famous Personalities (1970's) scale, and patients with obsessoidal personality features did somewhat better on the Personal Remote Memory Test. These temporary relationships with enduring personality traits did not occur among the non-ECT group, who were no different to the ECT group with respect to personality.

The level of sleeping tablet usage was associated with improved recognition of recent famous personalities, and the level of usage of tricyclic antidepressants was associated with a better recall from personal remote memory. Again, these beneficial side-effects of psychotropic medication did not occur within the non-ECT group, who were prescribed very similar amounts of hypnotics and antidepressants.

The ECT group performed significantly better than the non-ECT group on the correct alternations measure of the Mental Set Shifting Test at the four month assessment. On this test the ECT group did slightly better than the normal control group, and the non-ECT group slightly worse. The correct alternations measure is a direct operational measure of the ability to inhibit one set in order to assume a new, more difficult, set. Better performance on this measure implies that one is more able to appropriately control and direct a range of intellectual

processes. The functional significance of this regulatory capability cannot be over-stressed, particularly if cognitive processes are viewed in accordance with the principle of hierarchical organisation (Luria, 1973).

At the seven-month follow-up, only one test differentiated the two patient groups. This single difference should legitimately be ascribed to chance, as the test on which it occurred did not previously show a difference at the other comparison points. This test, Logical Memory, was a test of immediate verbal recall. If a decrement in it represented a genuine non-random cognitive impairment, group differences would probably also be detected on the five tests loading on the same factor as this test, to wit, Factor I (acquisition/learning). This was not the case.

The important point to be drawn from this is that the ECT group performed no worse overall than the non-ECT group, and that this lack of anything but the smallest of differences was consistent over time, occurring at least on two successive test occasions.

The trend for both patient groups throughout the study was toward recovery of cognitive function relative to the normal level. It is important to note, however, that the patient and non-patient samples were drawn from different populations. The most obvious difference between these

samples was that one was prone to severe depression requiring hospitalisation and vigorous psychiatric treatment, while the other was not. The entire non-patient sample had experienced no more than fourteen (14) verified depressive episodes in total, all of which were of the mild anxious/depression variety. None of these depressions lasted more than three months, and were treated by the General Practitioner ( $n = 10$ ) or required no formal medical treatment ( $n = 4$ ). There was a large "area of rarity" between the clinical samples and the non-patients. Of the 469 patients screened, 140 were insufficiently depressed to gain inclusion into this study, although they had gained admission to hospital. On the other hand, only 17 very severely depressed patients were not tested. It would not be surprising, then, to find, as this study did, that 4% - 21% of a battery of sensitive psychometric tests at follow-up detected small differences in cognitive function. It is noteworthy, however, that both patient samples, despite the undoubted severity of their emotional problems (that required continued prophylactic medication in many cases), were able to approximate so closely to the non-patient level.

Both patient groups had slower response execution times than did the non-patient group. In common with the findings of Shapiro and Nelson (1955), Friedman (1964), and Malone and Hemsley (1977), who found slowing to be

sensitive to depressive severity, this study also detected such relationships for the group who received ECT before treatment, and at both long-term follow-ups. Unlike Byrne (1976a), this study also found significant relationships between endogenous depressive type and slowed Movement Time. The contribution of the diagnosis-age interaction was smaller in this study than in Byrne's (1976a) study. However the most notable relationships with small decrements in Movement Time were those with the use of all common types of psychotropic medication. This relationship was also seen in the analyses of covariance of patients specifically complaining of ECT-related memory problems described by Freeman, Weeks, and Kendell (1980).

The principal finding of this research is that ECT, when used as a treatment for depression, does not normally produce enduring effects on cognitive function. Collateral evidence, from a detailed correlational analysis, showed that there was no relationship between the number of ECT treatments in the index treatment course and cognitive test results at follow-up. This uniform non-relationship applied to data from patients who received either bilateral ECT or unilateral ECT. Cumulative life-time dosage of ECT was significantly correlated on only 6 out of 186 (or 3%) possible test score correlations. Number of treatments in the index course was significantly correlated on only 1 out of 78 (or 1.3%) possible test



score correlations. This finding is congruent with that of Squire and Chace (1975), who also recorded nonsignificant correlations between numbers of ECT and memory test scores.

When the ECT and drug-treated groups are compared with the normal control group, both patient groups show deficits at four and seven months on some tests. Thus patients who complain of memory impairment after treatment are probably not imagining the presence of their disabilities. They are slightly impaired. This is probably related to the medication they are taking, or to persistence or recurrence of their depressive symptoms. Depressive severity accounted for 7% - 9% of the variance between the patient groups at long-term follow-up and the non-patient group. However, on specific cognitive tests at follow-up, e.g. Movement Time, Famous Personalities of the 1960's, Personal Remote Memory, and Logical Memory, depressive severity accounted for between 9% to 21% of the variance within the patient groups. Only four subjects in the non-patient group were taking psychotropic medication in contrast to the great majority of the patients. On specific cognitive tests at follow-up, e.g. Movement Time, Fluid Movement, and Famous Personalities of the 1960's, the level of psychotropic medication accounted for between 8% to 25% of the variance within the patient groups.

The replies to the Cognitive Failures Questionnaire (CFQ) showed that soon after admission and at follow-up both ECT and non-ECT patient groups complained to an equal extent about memory impairment. However, the general level of memory complaints from the matched volunteer control subjects was as high as that of the patients. Close examination of inter-correlations with the questionnaire data showed that the ECT group was slightly more accurate at assessing the severity of their very real cognitive difficulties, but only prior to treatment. This group, at the initial testing, was significantly inferior to the normal level and the non-ECT group's level. However, they were not actually impaired on three of the seven tests which were then correlated with more CFQ complaints. Likewise, the non-ECT group was not actually impaired on one of the two tests which for them were inversely correlated with more CFQ complaints.

Broadbent, Cooper, Fitzgerald, and Parkes (In Press) also have found no significant relationships between the CFQ and immediate memory for 9 item lists visually or acoustically presented, for the size of the effect of an acoustic suffix, for the size of the effect of articulatory suppression, for efficiency at the identification of blurred words, for long-term memory for categorised material, and for performance on the Williams Delayed Recall Test. These negative findings are congruent with the factor analysis reported in the Normative Studies Section, in

which the CFQ was shown to be independent of cognitive function factors composed of objective tests; and coextend the work of Kahn, Zarit, Hilbert, and Niederehe (1975).

If subjective memory complaints cannot be reliably related to psychometric test deficits, an alternative explanation can be found in the relationship with common neurotic symptoms, which has been replicated (Parkes, 1980; Broadbent et al, In Press; Graham-White, Weeks, and Wilkinson, in preparation). Subsidiary evidence presented by Parkes (1980) amplified this association further in that increased levels of exogenous stress significantly increased the correlation between neurotic symptoms and reported cognitive values. Broadbent et al (In Press) also document very high correlations between the CFQ and an independent psychiatrist's systematic assessment of observed fatigue and lack of concentration (but only in female patients). A proportion of depressed patients and non-patients do fulfil many or all of these possibly potentiating conditions or vulnerability factors - stress, fatigue, partial lack of concentration, and female sex. In addition, patients with psychotic affective disorders have been shown to dissimulate to a significantly higher degree than non-patients; much of this tendency remained after the improvement of the depressive illness (Verma, 1979).

Unilateral, non-dominant ECT was equivalent to bilateral

ECT for therapeutic efficacy, and superior to bilateral ECT in practically every other respect. Memory disturbance was significantly reduced with the former method of administration. This lack of co-variation supports the view that memory impairment is not an integral or even a remotely relevant component of favourable response to electroplexy. The findings of Turek and Block (1974) would support this view. On the basis of the present research, a case could be put forward for quite a different hypothesis - that the minimisation of cognitive dysfunction contributes to a somewhat more efficacious relief of depression. Equivocal evidence for this is the significant, but low, correlations between lower-rated levels of depression and less impaired long-term memory one week after treatment.

Unlike the research trials conducted by Stein Jensen (1968), and Heshe et al (1978), there were no significant group differences in the total dosages of electrical current per patient or in the number of double ECTs required per patient. Similar to the researches of Halliday et al (1968), Valentine, Keddle, and Dunne (1968), Zinkin and Birtchnell (1968), d'Elia (1970) and Stromgren (1973), there were no significant differences between the bilateral and unilateral groups on the number of ECTs received.

Because the longer term side-effects of ECT in general

are small and transient, the only occasion on which differences between unilateral and bilateral ECT could be detected was at one week post-ECT. These differences were confined to tests representing the factors of Delayed Retrieval and Learning. That the most significant of these differences does not involve faulty learning or increased forgetting directly, but rather the superimposition of excessive false positives on a Verbal Delayed Recognition Test, requires further exegesis. This phenomenon is not without precedent: Williams (1950), showed patients a number of pictures in the immediate post-ECT confusional period, then recorded their verbal responses. The first time the stimulus was presented, the patient would put forward several inappropriate responses which were actually approximations of the correct word. After the patient found the appropriate response in his verbal repertoire, the entire sequence of verbal behaviour could be triggered again several minutes later by re-displaying the original visual stimuli. The sequence would again include the earlier approximations.

The increased false recognition of structurally similar words by the bilateral ECT patients in the present research can be viewed as a much milder version of the nominal approximations reported by Williams (1950). This would imply that there is at least partial continuity between the post-ECT confusional state and the later recovery phases. However, opting for these irrelevant words did not prevent the discovery of the required words; there

were no differences between the ECT groups on the verbal memory sensitivity measure. Therefore these literal paraphasias are not sufficiently strong to be equally probable alternatives. They represent minimal interference to wholly efficient recognition, but might pose more of a problem in the case of cued recall or free recall.

The other documented instance of the occurrence of false positives after ECT, (Heshe et al, 1978), showed that they are not specific to verbal memory, or to delayed recognition, or to bilateral treatment. However, their bilateral ECT patients did commit significantly more false positives on a wider range of visual memory tests at 8 days post-treatment. To summarise, it appears as if bilateral ECT more easily releases inappropriate false positives in both visual and verbal memory than does unilateral ECT, but this effect is short-lived and does not necessarily or greatly interfere with the remembering of true positives.

Both visual design learning and auditory-verbal learning were more impaired by bilateral ECT than by unilateral non-dominant ECT soon after treatment. Visual design learning and delayed recall were somewhat more impaired than auditory-verbal learning, but this was probably related to the fact that these former tests provided more opportunity for dual encoding, verbal and visual. This



potential might be relatively more disturbed by bilateral treatment. Although the auditory-verbal learning test provided word pairs of high imagery and high concreteness, verbal association processes probably take precedence for most people. These would also be disturbed by bilateral treatment, involving as it does, the cerebral hemisphere that is dominant for language.

Four of the five tests (Delayed Recall and Delayed Recognition, Incidental Visual Memory and Logical Memory) on which the bilateral ECT group improved significantly between one week and three months post-treatment, have several features in common. The first of these is that the former three have to do with retention, or retrieval from long-term memory after an occupied delay. None of the material in any of them were learned to a specified criterion; most were measures of retention after one-trial learning, or retention after spontaneous, non-deliberate learning. All four would be easily susceptible to dual encoding, from verbal to visual or vice versa. Also, these four tests could all have been adversely effected by the type of false positive intrusion, or minimal psychometric confabulation, mentioned above. It is possible however that the retrograde amnesic effects of ECT, which are known to be increased by bilateral treatment (Squire, Slater, and Chace, 1975; Kozma and Galbraith, 1968; Zinkin and Birtchnell, 1968) may have also contributed toward the small decrement in Incidental



Visual Memory within the bilateral group at one week post-ECT. The patients in this group may not have had access to the single memory that the Positional Learning Test array would be followed by questions about it later. Therefore this array might not have acted as a trigger for them to deliberately remember its details, as it probably did do for the unilateral ECT group, non-ECT group, and non-patient group at retest.

To summarize the bilateral-unilateral ECT comparisons, unilateral ECT was just as effective as an antidepressant treatment and appeared to cause virtually no impairment in cognitive functioning, even in the short term. These results add weight to the view that unilateral ECT to the non-dominant hemisphere is preferable to bilateral ECT for the treatment of the majority of patients requiring ECT. Bilateral ECT should be reserved for depressed patients whose cerebral dominance cannot be ascertained, for patients with treatment-resistant depressions, and for patients in whom a generalised convulsion cannot be produced by unilateral treatment. However, these recommendations should be viewed as provisional until there is a close examination of variables which may differentially predict better response to either bilateral ECT or unilateral non-dominant ECT. A subsidiary analysis, a cross-over design of patients who do not respond well to one of the placements, would have a similar objective.

The directions that further research in this field takes should partly be guided by the omissions and limitations of previous research. The variables in need of further study are those to do with either different treatment parameters or with subtler tests.

Within treatment parameters, both the electrical characteristics (e.g., sine wave or brief-pulse stimulation) and electrode positionings should be compared in double-blind random allocation studies. Various electrode positions have been suggested for use, most of which have been equally efficacious for the alleviation of depressive symptoms. These positions should be systematically varied to find the ones that produce the slightest adverse side-effects.

The effects of ECT on long-term memory are in need of more refined psychometric scrutiny. To do this, the Famous Personalities Test procedure should be repeated using free or cued recall instead of recognition, and by presenting pictures of the personalities' faces instead of their names. Long-term memory temporal sequencing (Underwood, 1977) should also be investigated, as this researcher gained the impression that there were weaknesses in this amongst many patients. A test of the memories for British single-season television programmes should be devised and used with applicable patients.

"Flashbulb" memories, personalized recollections of the individual's circumstances surrounding the news of a public event, e.g., "What were you doing when you heard about President Reagan being shot?", could also be studied. In the light of Squire et al's (1981) findings, a reliable multiple-item test of recent personal memories, covering the three years before the first ECT administered to the patient, should be devised. In regard to this test, the final follow-up should be extended to at least nine months, to assess further memory reinstatement.

Patients who believe that ECT has caused them permanent memory problems present further questions in need of examination. Other factors, i.e., psychotropic medication, level of depression, neurotic symptoms, age, and social class, have been implicated as significant co-variants to explain some of the test differences between ECT complainers, ECT non-complainers, and non-patient controls. (Freeman et al, 1980.) Out of 26 ECT complainers tested by the author, two further individuals were chronic schizophrenics, two abused alcohol, and one subject was diagnosed as suffering from systemic lupus erythematosus (SLE) shortly after testing. However, in a small proportion of these patients, there seemed to be no ready explanation for their poor test results.

The most convincing complainers, who had no obvious

explanation for their poor memory, appeared to have nothing in common. They had not had excessive amounts of ECT, nor had their ECT been more recent than the other complainers, nor were there any complications during their treatment. There were no comments in their case-notes about things having gone wrong, such as prolonged hypoxia, missed seizures or subconvulsive shocks. A few patients were clearly complaining of the retrograde amnesic effects, but several more had probably made faulty attributions.

Depression itself perversely interferes with the motivation to learn and the ability to learn; ECT rectifies the former, though it temporarily interferes with the latter. This diminished ability (more pronounced with bilateral ECT) when motivation returns may be disturbing or annoying to some patients. This interference might be remembered long after it has subsided, due to the fact that ECT is an ineffective amnesic stimulus.

It may be that ECT does cause some degree of permanent memory impairment in a very small proportion of all the patients who receive it, but this researcher considers that the research reported herein and other comparisons of carefully matched groups of patients receiving ECT or drug treatment indicate convincingly that ECT does not normally produce enduring effects on memory.

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## APPENDIX

Content of the initial interview by the research psychiatrist.

Name	Previous psychiatric illness
Address	Number of episodes of depression
Housing	Number of episodes of mania
Occupation	Previous ECT
Age	number of treatments
Sex	dates of treatments
Marital Status	Smoking data
Education	Alcohol consumption data
	Physical illness history
	History of possible head injury
	Current medication summary

## Subjective Side Effects Questionnaire

(Items include muscle pain, headache, sore throat-nasal congestion, nausea, confusion, memory impairment, dizziness, other; rated on 4 point scale of severity: symptom absent, mild, moderate, or severe.)

Hamilton Rating Scale

Wakefield Self-Rating Scale

Visual Analogue Scales

AppendixStimuli for Verbal Learning and Verbal Memory Test

<u>Stimulus</u> <u>Word</u>	<u>Response</u> <u>Word</u>	<u>Semantic</u> <u>Distractor</u>	<u>Structural</u> <u>Distractor</u>
<u>(Form A)</u>			
river	water	flood	waver
metal	iron	lead	isle
table	grass	clover	gross
joy	happiness	gladness	handiness
idea	hint	clue	hilt
concept	proxy	stand-in	prowl
<u>(Form B)</u>			
ocean	sea	bay	tea
tobacco	pipe	cigar	pike
boy	hammer	wrench	handle
fate	belief	trust	relief
truth	justice	fairness	jungle
foible	gist	drift	guile
<u>(Form C)</u>			
child	mother	parent	moisture
priest	church	chapel	churn
earth	harp	guitar	heart
moment	unit	item	unique
context	adage	saying	addition
health	sickness	illness	signet
<u>(Form D)</u>			
hand	glove	mitten	gloss
tree	apple	pear	aptly
army	diamond	sapphire	dieter
courage	brave	heroic	braid
fact	excuse	pardon	exclude
interim	forethought	insight	foreshore

AVR RECORD SHEET

INITIAL PRESENTATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Metal - Iron	1	2	4	3	1	5	6	4	3	5	1	6	4	5	1
Idea - Hint	2	4	5	4	3	3	2	5	1	6	3	3	6	1	3
River - Water	3	5	6	2	2	4	1	3	6	1	4	2	2	3	5
Concept - Iroxy	4	1	1	6	3	6	4	6	5	2	2	5	3	2	4
Joy - Happiness	5	3	2	1	4	2	5	1	4	3	6	1	5	4	6
Table - Grass	6	6	3	5	6	1	3	2	2	4	5	4	1	6	2

INSTRUCTIONS: "I am going to read you a list of words, two at a time. Listen carefully because, after I finish, I shall want you to remember the words that go together. For example, if I said the words 'Gold - Silver', 'East - West', then when I say the word 'Gold' you will say 'Silver' and when I say the word 'East', you will say..... (pause) 'West'. Do you understand? Now listen carefully to the list as I read it."

NAME:.....

SCORE:.....

APPENDIXPERSONAL REMOTE MEMORY TEST

1. Have you ever been in any other hospital(s) previously?  
 Name(s) of hospital(s) .....  
 .....  
 When were you at that hospital?.....  
 .....
2. Can you tell me the name of a doctor who was treating  
 you in the past?.....  
 When was he your doctor?.....
3. How long were you in hospital the last time?.....  
 .....
4. What was the name of your first school?.....  
 .....
5. Can you remember a teacher that you had in your first  
 year at school?.....  
 in your second year at school?.....
6. Can you remember the name of another child who was with  
 you in your first year at school?.....  
 in your second year at school?.....
7. After you left school, can you remember where you were  
 when you first met your best friend?.....  
 .....
8. Can you remember the name of the very first film that you  
 ever saw?.....  
 How old were you then? (or, When was that?).....  
 .....
9. Can you remember the name of the most recent film that  
 you have seen?.....  
 When was that? (or How long ago was that?)  
 .....

10. Can you tell me the name of the first school your  
(son, daughter) attended?.....  
.....
11. Who suggested to you that you ought to come into this  
hospital (on this occasion)?.....  
.....
12. What day of the week was it when you were admitted to  
this hospital?.....
13. What was the date when you were admitted to this  
hospital?.....
14. What time of day was it when you arrived at the hospital  
(on your day of admission)?.....
15. Can you remember coming to the hospital? If Yes, Who  
brought you to the hospital?.....  
.....
16. Can you tell me the name(s) of any of the other patients  
on your ward?.....
17. Can you tell me the name(s) of any of the nurses on the  
ward?.....
18. What did you have for your dinner yesterday?.....  
.....
19. What have the newspaper headlines been about these days?  
.....  
.....  
or What has the news on the television been about recently?  
.....  
.....

20. When did you last go away on holiday?.....  
.....
21. Where did you go (on your last holiday)?.....  
.....
22. How long was that holiday?.....  
.....
23. What is your earliest memory (from when you were a  
small child)?.....  
.....  
.....  
.....  
.....
24. How old were you then?.....
25. Have you had any dream in the past that you can still  
remember (recurring or otherwise)?.....  
.....  
.....  
.....  
.....

PERSONAL REMOTE MEMORY TEST - SUPPLEMENTARY FORM

1. What was the first address that you lived at (as a child)?.....
2. Were there any moves from that address? If Yes, When? (how old were you then?).....
3. To what address did you move to then?.....
4. What is your wedding anniversary?.....
5. What is your husband's (or wife's) birthday?.....
6. Where does your husband (or wife) work?.....
7. How long has he (or she) worked there?.....
8. Do you know his (or hers) telephone number at work?.....
9. Do you own a car? If Yes, where did you purchase it?.....
10. Could you tell me your children's birthdays? (or ages)?.....
11. Could you tell me your grandchildren's birthdays? (or ages)?.....
12. Are any of your children married? If Yes, can you tell me when?.....



13. Have you ever had any operations or surgery? If Yes,  
what were they for, and when did you receive the?  
.....  
.....  
.....
14. When you were in this hospital, did you receive any  
occupational therapy? .....
15. If Yes to 14), What were you making?, or What activity  
were you doing?.....  
.....
16. Do you remember the names of any of the Occupational  
Therapists?.....
17. Who informed you that you needed to have ECT (or  
antidepressant medication)?.....  
.....
18. How many treatments of ECT have you had? or How many  
different kinds of tablets have you had?.....  
.....
19. When did you receive the most recent ECT treatment? or  
When was the last time your antidepressant medication  
regime was altered?.....  
.....
20. What were the events leading up to your admission to  
this hospital?.....  
.....

FAMOUS PERSONALITIES RECOGNITION (A)

I am now going to read you a list of peoples' names, some of whom have been famous in the past or are famous at the present time. Some have only been slightly famous; these people have been famous in various walks of life, therefore you might not have heard of them all by any means. If the name sounds familiar to you, if you recognize it say "yes". If you do not recognise it at all, say "No". If you are not sure or if it is only vaguely familiar to you, then say "Not sure". Any questions?

1930s

DOROTHY ROUND  
 PIERRE LAVAL  
 HENRY LEWIS STIMSON  
 ALAN MORTON  
 DON BUDGE  
 BILL EDRICH  
 RICHARD TAUBER  
 JOANNIS METAXAS  
 JESSIE OWENS  
 STEVE DONOGHUE  
 MARY KAPLAN  
 ANGELA PALMER  
 LUCILLE HOGAN-KEMP

1950s

LONNIE DONEGAN  
 CHRIS CHATAWAY  
 CLAIRE TRISTE  
 HUGH WAINBRIDGE  
 JENNIE LEE  
 BILLY WRIGHT  
 DAG HAMMERSKJOLD  
 RUBY MURRAY  
 JACKIE MILBURN  
 PARRY O'BRIEN  
 KENNETH YOUNGER  
 ARTHUR DEAKIN

1940s

ERNEST BEVIN  
 ISSY BONN  
 STANLEY MORTENSON  
 BRUCE WOODCOCK  
 JOSEPH LOCKE  
 MARIANNE ZEVELEY  
 EDWINA LEDUR  
 MARGE TYLER  
 WILLIAM MACKENZIE KING  
 ARTHUR MORRIS  
 STUARD HIBBARD  
 RALPH BUNCHE  
 JONNY CAREY

1960s

DR. BEECHING  
 HELEN SHAPIRO  
 FRANK COUSINS  
 FLIP WEIR  
 LEO MOTZIRO  
 RONALD BIGGS  
 TRINI LOPEZ  
 ROY EMERSON  
 DAVID HEMMERY  
 JOHN DIEFENBAKER  
 JIMMY ARMFIELD  
 PETTY WHICKHAM

FAMOUS PERSONALITIES RECOGNITION (B)1930s

Hetty King  
 Huey Long  
 Monty Banks  
 Wendell Wilkie  
 Fred Perry  
 Arthur Henderson  
 Sonja Henie  
 Sir Charles Portall  
 Betty Nuthall  
 Brenda Frazier  
 Jessie Laughton  
 Laura Whalen  
 Boris Milne

1950s

Clement Attlee  
 Russell McQuade  
 Bobby Darin  
 Ross Simmonds  
 Mauréen Connelly  
 Pat Hornsby Smith  
 Eve Boswell  
 John Foster Dulles  
 Teresa Brewer  
 Nat Lofthouse  
 Wilf Mannion  
 William Drees

1940s

Fanny Blankers-Koen  
 Gussie Moran  
 Len Shackleton  
 Hugh Dalton  
 William Beveridge  
 Rosa Troupin  
 Vivian Kenney  
 Thomas Yuill  
 Bryan Marshall  
 Trygre Lie  
 Ray Yesner  
 Leon Blum  
 Norman Bailey Stewart

1960s

Kenny Ball  
 Vidal Sassoon  
 Millicent Martin  
 Christine Keeler  
 Cliff Maloney  
 Henry Maitland  
 Rod Laver  
 Jimi Hendrix  
 Nobby Stiles  
 Heathcote Amory  
 Johnny Haynes  
 Robert Fraser

FAMOUS PERSONALITIES RECOGNITION (C)1930s

Evelyn Laye  
 Engelbert Dollfuss  
 Alex James  
 Jeanette McDonald  
 Sir Samuel Hoare  
 Edith Nettleton  
 H. Wragg  
 Roy Fox  
 Ella Reeves Bloor  
 Florrie Ford  
 Rosamund Colley  
 Alan Walton  
 Kingston Montague  
 Ken Rosewell

1950s

Ken Rosewell  
 Talbot Spencer  
 Rocky Marciano  
 Waldo Lamb  
 Ruth Ellis  
 David Ben-Gurion  
 Tom Graveney  
 Anthea Gibson  
 Norma Anne Sykes  
 Estes Kefauver  
 Richard Bergmann  
 Dawn Palethorpe

1940s

Len Hutton  
 Henry Cotton  
 Fred Rimmell  
 George C Marshall  
 Anne Shelton  
 Alex Watt  
 Mark Houghton  
 Ian Swan  
 Ellen Wilkinson  
 Jean Francois Darlan  
 Tino Rossi  
 Joe Di Maggio  
 Eden Ahbez

1960s

Cilla Black  
 Christian Barnard  
 Bobby Charlton  
 Konrad Adenauer  
 Anita Lonsborough  
 Edwin Kilbourne  
 Roderick Acland  
 Dr. Barbara Moore  
 Bobby Fischer  
 John Bloom  
 Timothy Leary  
 Don Thompson

FAMOUS PERSONALITIES RECOGNITION (D)1930s

Jack Hobbs  
 Hedley Verity  
 Vyvyan Adams  
 Jan Masaryk  
 Deanna Durbin  
 Sir John Simon  
 Sir John Anderson  
 Herbert Hoover  
 Harry Champion  
 Tommy Farr  
 Mary Grunlast  
 Carson Grieve  
 Paul McGuire

1950s

John Costello  
 Herb Elliot  
 Zoe Newton  
 Adrian Vickery  
 Dick Francis  
 Peter Townsend  
 Joe McCarthy  
 Rab. Butler  
 Alan Cogan  
 Lisa Corin  
 Mervin Figley  
 Rosemary Clooney

1940s

Carroll Gibbons  
 J. Robert Oppenheimer  
 Maxime Weygand  
 Cliff Bastin  
 Stanley Mathews  
 Paula Stremple  
 Oriole Resolve  
 Charles Hoy  
 Jack Kramer  
 Peter Doherty  
 Odette Hallowes  
 Peter Thompson  
 Harrison Dillard

1960s

Sir Francis Chichester  
 Myra Short  
 Harry Connie  
 Kathy Kirby  
 Peter Maxx  
 Dorothy Hyman  
 Terry Downes  
 Frank Worrell  
 Adolf Eichmann  
 Herb Alpert  
 Jean Shrimpton  
 John Profumo

FAMOUS PERSONALITIES RECOGNITION (E)1930s

Charles Lindberg  
 Mrs. Simpson  
 Ambrose  
 Viscount Halifax  
 Al Boley  
 Edouard Daladier  
 Prince Obolensky  
 Reggie Whitcombe  
 Jimmy Lanceford  
 Jack Hylton

1940s

Lena Horne  
 Dick Haynes  
 Sir John Boyd-Orr  
 Lord Tedder  
 Harry Hopkins  
 Lord Woolton  
 Keith Miller  
 General Neil Richie  
 Bobby Riggs  
 Edgar Sanders

1950s

Peggy Lee  
 Lord Boothby  
 Moshe Sharett  
 Winifred Atwell  
 Johnny Ray  
 Alan Ginsberg  
 Sugar Ray Robinson  
 Pierre Poujade  
 Sir Sidney George Holland  
 Mario Lanza

1960s

Jim Clark  
 Sandie Shaw  
 Dick Crossman  
 Andy Williams  
 Dr. Banda  
 Earl Warren  
 Fred Winter  
 Adlai Stevenson  
 Ray Wilson  
 Alec Douglas-Home

1970s

Pierre Trudeau  
 Tony Blackburn  
 Jess Yates  
 John Denver  
 H.R. "Bob" Haldeman  
 Tim Brooke-Taylor  
 Norma Levy  
 David Soul  
 Emerson Fittipaldi  
 Michael Heseltine

L

Alison Riddons  
 Sean Hulroy  
 Margaret Luby  
 Matthew Stellar  
 Patricia Curtois  
 Cyril Pondsley  
 Mavis Malcolm  
 Luke Apjack  
 Hazel Galant  
 Davinia Dawson

## Famous Personalities Test (continued)

(Early 1970's)

NAME .....

SCORE .....

(A)

William Whitelaw  
 John Newcombe  
 Harry Nilsson  
 Richard Neville  
 Gerald Ford  
 Shirley Williams  
 Yoko Ono  
 Aristotle Onassis  
 Pat Eddery  
 David Bowie

(B)

Marc Bolan  
 Elton John  
 Mary Peters  
 Graham Thomson  
 Johan Cruyff  
 Tony Jacklin  
 Gary Glitter  
 Lord Lucan  
 Georges Pompidou  
 Val Doonican

(C)

Willy Brandt  
 John Conteh  
 Uri Geller  
 Jeremy Thorpe  
 Nana Mouskouri  
 Telly Savalas  
 Henry Kissinger  
 Brendan Foster  
 Pat Jennings  
 Harold Wilson

(D)

John Stonehouse  
 Idi Amin  
 Dennis Lillee  
 Billy Bremner  
 Mark Spitz  
 Donny Osmond  
 Liza Minnelli  
 Gordon Banks  
 Yvonne Goolagong  
 Richard Nixon



SENTENCE RECALL

NAME \_\_\_\_\_

Instructions: "I am now going to read some individual sentences. Listen carefully now to each sentence and repeat it immediately after I stop reading it. The sentences may be quite meaningless and the usual word order may be changed. Your task is to repeat word for word what I say. Are you ready?"

Practice sentences      This is the way to the new park.  
                                  The field breaks the bank luckily the bronze.

(1) Colourless green ideas sleep furiously by teatime.

---



---

(2) The sky, that the dream thought, jumped cheaply.

---



---

(3) Wasn't the fat ceiling robbed by the tired pen?

---



---

(4) The man, that the book read, was interesting she flies.

---



---

(5) Wasn't the rich uncle advised by the nice book manager?

---



---

(6) Not in tree to the ran lake with repair.

---



---

SCORE \_\_\_\_\_

SENTENCE RECALL FORM BPractice Sentences

Errors \_\_\_\_\_

Score \_\_\_\_\_

This is the street to the new building.

The stream burns the hair seriously now.

- 1) Travelling white minutes rise transparently at football.

\_\_\_\_\_

\_\_\_\_\_

- 2) The car, that the hope shared, walked clearly.

\_\_\_\_\_

\_\_\_\_\_

- 3) Wasn't the cold summer leased by the hungry cloth?

\_\_\_\_\_

\_\_\_\_\_

- 4) The woman, that the money shared, was famous it grows.

\_\_\_\_\_

\_\_\_\_\_

- 5) Wasn't the smart banker offered by the thin young clerkess?

\_\_\_\_\_

\_\_\_\_\_

- 6) Not in house to the walked dance with sharpness.

\_\_\_\_\_

\_\_\_\_\_

SENTENCE RECALL FORM CPractice Sentences

This is the way to the old fountain.

The wrist bends the arm fortunately well.

- (1) Shadowless seen notions float magically by dinner.

---

---

- (2) The cat, that the breeze laughed, swam keenly.

---

---

- (3) Didn't the mild picture swing by the bought flask?

---

---

- (4) The boy, that the pencil writes, was possible they walk.

---

---

- (5) Wasn't the poor salesman pleased by the eager product?

---

---

- (6) Not in walls to the hunter's rain with poetry.

---

---

Errors \_\_\_\_\_

Score \_\_\_\_\_

SENTENCE RECALL FORM DPractice Sentences

This is the road to the old house.

The garden shows the rose happily the clouds.

(1) Windowless clean moments weigh gorgeously at cricket. \_\_\_\_\_

(2) The dog, that the song cares, cooked nearly. \_\_\_\_\_

(3) Didn't the machine prove formed by control string? \_\_\_\_\_

(4) The girl, that the banana eats, was silent he builds. \_\_\_\_\_

(5) Wasn't the tanned lifeguard rescued by the slim girl bather? \_\_\_\_\_

(6) Not in clocks to the chance paper with reason. \_\_\_\_\_

Errors \_\_\_\_\_

Score \_\_\_\_\_

LATERALITY CHECKLISTHAND -

- (1) Writing
- (2) Hand posture
  - (a) Pen point toward top of page
  - (b) Hand below point
- (3) Use a toothbrush
- (4) Knife and fork. K in R, F in L.
- (5) Use scissors
- (6) Throw a ball to hit a target
- (7) Taking the lid off a box
- (8) Use a hammer

.....

- (9) Dealing cards

(a) Time from R \_\_\_\_\_ Time from L \_\_\_\_\_ CD avg \_\_\_\_\_

.....

EYE

- (10) Kaleidoscope
- (11) Point to E's nose
- (12) ABC instrument
- (13) Bombsight

FOOT

- (14) Kick a football

RELATIVES LEFT-HANDED

RELATIVES AMBIDEXTEROUS